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EDICAL

AND

OPERATIVE

APPLIED ANATOMY.

APPLIED ANATOMY

SURGICAL, MEDICAL,

AND

OPERATIVE.

BY

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TO

JOHNSON SYMINGTON, M.D.,

F.R.S.E., F.R.C.S.E.,

LECTURER ON ANATOMY, SCHOOL OF MEDICINE, EDINBURGH,

IN RECOGNITION OF HIS GREAT SKILL AS A TEACHER
AND AS AN EXPRESSION OF SINCERE REGARD,

This Book is respectfully Dedicated

BY

AN OLD PUPIL.

PREFACE TO THIRD EDITION.

IN preparing this Edition much new matter has been added, and the book rendered more complete in every respect, especially in the parts treating of MEDICAL ANATOMY. I trust the time is not far distant when a book such as this will be used by every Medical Student *before* he has left the dissecting-room, for there is nothing in it—excluding the mere details of Operative Surgery—that he could not get up much better, and more easily, during the time he is preparing for his Anatomical and Physiological examination: for Anatomy is but the handmaid of Surgery—but the dry bones, into which Surgery breathes the breath of life. Were such a course pursued, the examination in Surgery, instead of being the bugbear it is to so many Students, would become the easiest and most satisfactory part of the whole examination.

A large number of new Illustrations have been added, the plates of which have been engraved partly by Miss E. P. Hill Burton and partly by Mr David L. Turnbull, to both of whom I now desire to express my thanks.

My thanks are also specially due to Dr Symington for the use of Fig. 119, showing the position of the mastoid antrum, and also for the use of the bones, showing the various epiphyseal lines, from which the engravings were made by Mr Turnbull; and to Dr Wallace, Senior Assistant to the Professor of Surgery, for photographs of the same.

For Figs. 42 and 43 of the present volume I am indebted to the kindness of Professor Cunningham.

I am also indebted to Dr F. M. Caird for a number of the sketches from which the Wood Engravings have been drawn.

I have also to express my thanks to Dr Aitken, who has rendered me much valuable assistance in the revision of the proof-sheets.

The Second Volume will be produced with as little delay as possible.

J. M'L.

EDINBURGH, *April 1889.*

EXTRACTS FROM PREFACE

TO

SECOND EDITION.

IN preparing the following pages for the press, I have endeavoured to write, as a Student, to Students; in this way I hope I have been enabled more thoroughly to meet the wants of Students preparing for the various Final Examinations throughout the Kingdom. The present book is intended to replace a small book I published some years ago, but is to be regarded as essentially different in all respects. It is intended to be sufficient for the various Higher Examinations, as well as for those of less severity, and especially is it intended for those Examinations that require actual operations on the dead body as part of the Final or Pass Examination. The *Lancet*, in its kind and favourable review of my first book, drew attention to some points wherein it was deficient—chiefly in relation to "Surface Anatomy." I trust the present book is less deficient in that respect, but there are some things that cannot be learned except beside the living, or dead, body. I have certainly pointed out the special relations of the various important bony points that can be felt, or seen, on the surface of the body; but to learn the Surface Anatomy properly,

the Student *must* have the actual body beside him to see and feel for himself.

The greater number of the engravings are original—most of them being prepared from rough sketches by the Author; but for their elaboration and execution I must express my thanks to Mr David L. Turnbull, who has engraved all the plates, with but five exceptions. I must also express my thanks to Messrs Longmans, Green, & Co. for permission to insert Nos. 41 and 42, and to Professor Cunningham for permission to insert Nos. 59 and 60, as well as to his Publishers (Messrs Maclachlan & Stewart) for the ready and courteous manner in which they furnished the necessary electrotypes. If at times, in the drawings, I have sacrificed strict scientific accuracy, for the sake of impressing special points on the Student's mind, I must be excused, for what is the use of engravings unless they *impress* the idea they are intended to convey, and teach some practically useful fact.

J. M'L.

EDINBURGH, *May 1887.*

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* In Figs. 42 and 43 on page 223, *read* UPPER-ARM *instead of* FORE-ARM.

APPLIED ANATOMY:

SURGICAL, MEDICAL, AND OPERATIVE.

CHAPTER I.

ANEURISM.

In introducing the subject of Ligature of Arteries, I propose to say a few words concerning Aneurism in general, and its treatment. An **Aneurism** may be defined as a swelling containing blood, either fluid or coagulated, communicating with the cavity of an artery. Mr Erichsen thus classifies the different forms :—

I. Fusiform—True.
II. Sacculated.
  (*a*) True.
  (*b*) False.
    (1) *Circumscribed.*
    (2) *Diffused.*
III. Dissecting.

The cirsoid and arterio-venous varieties are not included in this classification. Formerly, a **true** aneurism meant one whose wall was formed by an equal dilatation of all the coats of the vessel; as a rule, it now means an aneurism whose wall is formed by one or more of the arterial coats.

I.—**Fusiform** or **Tubular Aneurism** consists of an equal expansion of *all* the coats of the vessel throughout its entire circumference; this form is most frequently met with in the arch of the aorta.

II.—By a **Sacculated Aneurism** is meant a tumour springing from the *side* of an artery, or from a tubular aneurism, with the interior of which it communicates by a narrow opening called the mouth of the sac. (*a*) In *true sacculated*, the sac wall is formed by all the coats of the vessel; (*b*) in *false sacculated*, the internal or middle coat, or both, are deficient, and the wall of the sac therefore is formed by the outer and middle coats only, or else by the outer coat alone. To this latter condition the name of *circumscribed false* aneurism is sometimes applied; *diffused false* aneurism means that the sac of the aneurism is not formed by the coats of the artery at all, but by the tissues outside the vessel; the blood being either confined by the condensed tissues of the part into a *circumscribed* tumour, or else widely *diffused* in the loose cellular tissue.

III.—**Dissecting Aneurism.**—In this form the internal coat of the artery becomes eroded, or an atheromatous abscess bursts, and the blood makes its way through the ulcer or erosion and burrows between the coats of the vessel. As a result of this, it may either burst through all the coats and be effused into the surrounding tissues, or, if the external coat be strong enough to resist the rupture, the blood travels along between the coats for some distance, and again opens into the cavity of the artery; or, thirdly, it may form a sac in the middle coat, which may remain for a time unaltered, but which will, in all probability, eventually burst externally. This form of aneurism is met with most frequently in women.

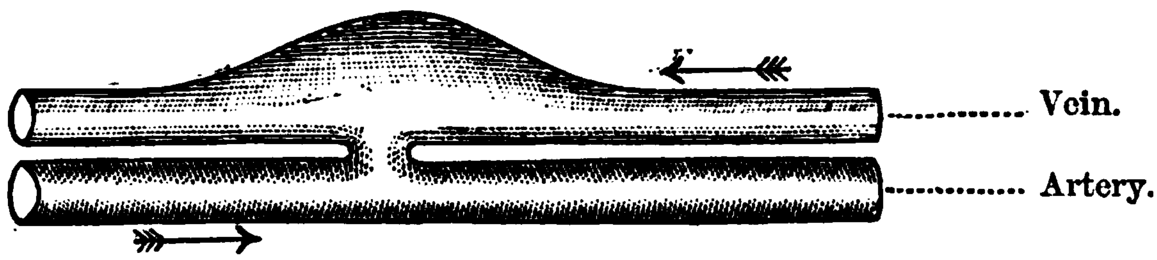
Various other methods of classification are adopted by different writers, *e.g.*, some divide aneurisms simply into:—(1) **True**, where the sac wall is formed by one or more of the coats of the vessel; this form being associated with *disease* of the artery. (2) **False**, where the tissues *outside* the vessel form the sac wall; this form being caused by a wound of the artery, or else by the bursting of a true aneurism.

Others again divide them into:—(1) **Spontaneous**, or that associated with disease. (2) **Traumatic**, from one of three forms of traumatism—(*a*) a direct wound; (*b*) a strain or bruise; or (*c*) the sharp end of a fractured bone penetrating the vessel. (3) **Arterio-venous.** (4) **Cirsoid.**

Arterio-venous Aneurism is usually caused by a wound which simultaneously implicates an artery and some neighbouring vein; in some rare cases it may arise from disease. There are two varieties:—(1) *Aneurismal varix* (Fig. 1), where the wounded artery and vein have adhered closely, and the inflammatory exudation, caused by the injury, has fixed them in this position, and

Fig. 1.

ANEURISMAL VARIX.

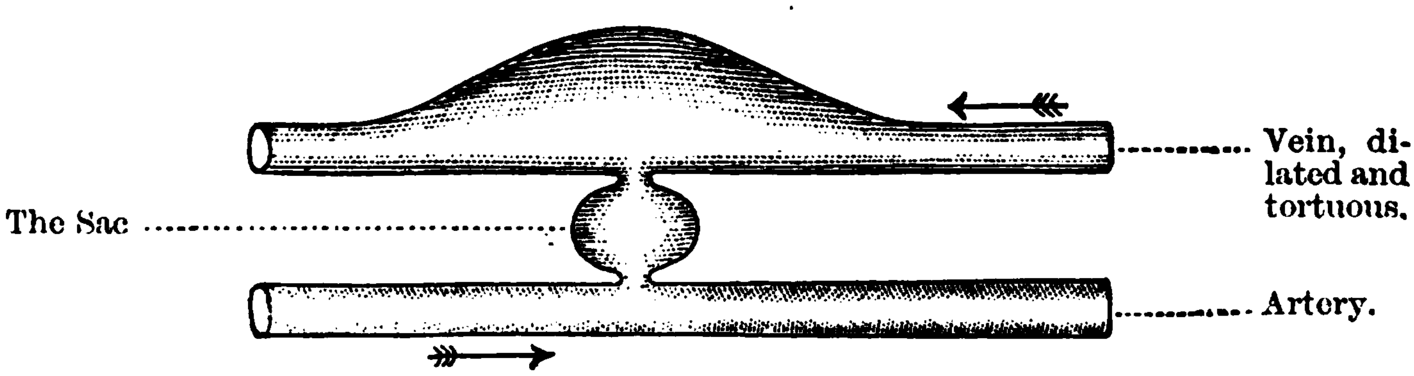


The arrows indicate the direction of the blood-stream.

at each pulsation a jet of arterial blood is projected *directly* into the vein, dilating it and causing incompetence of its valves, and gradually leading to a varicose condition of the neighbouring veins, both superficial and deep. The veins become tortuous, thickened, and may pulsate, but there is nothing of the nature of an aneurism formed. (2) *Varicose aneurism* (Fig. 2), where the lymph cementing the two vessels yields and an aneurism is formed,

Fig. 2.

VARICOSE ANEURISM.



The arrows indicate the direction of the blood-stream.

the wall of which consists of the new inflammatory material and condensed cellular tissue. The sac of the aneurism communicates with both the artery and vein, the blood being projected from the artery *through the sac* into the vein, dilating it as in aneurismal varix. By far the most frequent cause of arterio-venous aneurism is the unskilful performance of venesection at the bend of the

elbow, resulting in the simultaneous wounding of the brachial artery and the median basilic vein; it is but rarely seen now-a-days, since this operation is not often performed, and only by Surgeons. Any punctured wound, however, may cause it, *e.g.* from small shot, or a spicule of bone in comminuted fracture. In both forms there is a pulsatile dilatation of the veins, with a well marked thrill and a loud *continuous* murmur, increased in intensity at each cardiac systole, like the "*bruit de diable*" over the internal jugular vein in anæmia, and which has been likened to "the noise made by a blue-bottle fly confined in a thin paper bag;" the murmur is conducted with greatest intensity *along the veins*, and, therefore, towards the heart, and not from it, as in ordinary aneurism. The chief points of distinction between the two varieties are, that in *varicose aneurism* there is a more or less distinct tumour in addition to the other symptoms, and probably a double murmur—one, continuous and accompanied with a thrill, such as is always found when an artery and vein communicate; the other, systolic in time, like that usually found in aneurism.

A Cirsoid Aneurism is produced by the simultaneous elongation and dilatation of *arteries*, with thinning of all their coats; but especially of the middle, so that, in structure, they come to resemble veins. It forms an ill-defined compressible swelling, with expansile pulsation, and a soft systolic bruit (with sometimes a diastolic as well) heard with equal intensity at every part of its surface; on palpation, it is felt to consist of tortuous and sacculated tubes. The arteries most frequently affected are those of the scalp, hands, orbit, and iliac fossa.

In **Aneurism by Anastomosis** both arteries and veins are affected. The blood is not contained in vessels, properly speaking, but in large spaces or pools into which arteries empty themselves, and from which veins take their origin; the whole resembling very closely the condition found in cavernous tissues, or in the maternal part of the placenta. There is a well-marked thrill, and loud continuous bruit, like that found in arterio-venous aneurism; pulsation is only found at spots here and there—the points where the feeding arteries enter.

Causes of Aneurism.—Anything that destroys the balance between the expansive force of the circulation and the reaction

of the arterial wall; or, in other words, whatever increases the blood pressure on the one hand, or reduces the resisting force of the arterial walls on the other, as thinning of their coats or diminished resiliency. It is specially **apt to occur**—(1) In large vessels, because atheroma (the chief predisposing cause) is a disease of the large arteries; (2) in places subjected to great strain, *e.g.*, the axillary artery in sailors, probably from climbing, hanging by their arms, etc.; (3) where large arteries bend or bifurcate, because the pressure is greatest at these points, *e.g.*, the innominate, bifurcation of the common carotid, and popliteal. (*a*) **Predisposing Causes.**—Anything that gives rise to a *local* weakness of the vessel wall. The great predisposing cause is atheroma, but syphilis, gout, rheumatism, Bright's disease of the kidney (especially the granular contracted form), abuse of alcohol, intemperance, and vice of every form, are also important predisposing causes; and all the more so because many of these conditions are accompanied with hypertrophy of the left ventricle, so that not only is the vessel wall weakened but the blood pressure is increased as well. All occupations where sudden and severe efforts are required *irregularly*, as in soldiers, sailors, and huntsmen. It is said to be most common between the ages of thirty and forty. (*b*) **Exciting Causes.**—Wounds or blows, sudden strains, irregular vascular excitement, as from violent exercise or emotion, fits of anger, etc., in people of a certain age, say above fifty.

Symptoms of Aneurism.—The more important symptoms are—(1) The presence of a pulsating tumour near the known course of some blood vessel, and which cannot be separated, or moved apart, from the vessel. (2) Pressure on the artery above arrests the pulsations of the tumour, and may cause it to subside, but when the pressure is removed it refills again, often with a thrill; pressure on the artery below will cause it to become larger and more tense. (3) The pulsation is expansile, the tumour enlarging in all its diameters at each systole, and is not a mere thrust forwards. One may determine whether the pulsation is expansile or not in two ways—(*a*) By placing a finger on each side of the swelling and observing whether they are separated or simply raised; or (*b*) by fixing a piece of strapping, or elastic webbing, with a slit in its middle over the swelling, when, if the pulsation be expansile, the

slit will open out at each systole. (4) The pulse in the vessel beyond the aneurism is delayed, smaller and weaker than it should be. (5) Pressure effects, *e.g.*, pain, which may either be lancinating and intermittent, or continuous and aching, muscular weakness, and œdema from pressure on the veins. (6) Presence of a bruit and thrill. Note, that many of these signs will be absent in consolidation.

DIAGNOSIS.—(1) From **solid tumours** placed over large arteries —(*a*) The pulsation is chiefly felt along the line of the artery and not in the lateral expansions, and is heaving in character, not expansile; (*b*) the tumour is movable *in the course* of the artery as well as from side to side: aneurismal tumours are only movable laterally, not *in the length* of the artery; (*c*) it neither collapses nor is compressible when the artery above is commanded, nor is the tension increased when the artery below is compressed; (*d*) all movement is stopped at once by pressure on the proximal side of the tumour, and returns *at once* as strongly as ever when the pressure is removed: in an aneurism, the pulsation returns *gradually*, and does not attain its full force for a few seconds; (*e*) it may be pulled away from the artery when the pulsation is lessened, or lost altogether: in the abdomen, it may be possible to produce the same effect by making the patient support himself on his hands and knees, when the tumour will fall away from the pulsating artery; (*f*) bruit and thrill usually absent, and so also alterations in the arterial pulse beyond.

(2) From an **abscess** situated over a large artery—(*a*) An abscess forms an incompressible and immovable fluctuating swelling, and has an ill-defined outline; (*b*) it began with signs of inflammation, forming a solid swelling which has gradually softened. An aneurism begins as a soft swelling, and tends to become harder. (*c*) When the artery above is compressed, the pulsation stops, but returns *at once* as strongly as ever when the pressure is removed; further, the pulsation is felt mainly in the line of the vessel.

(3) **Cysts** are much more sharply defined than abcesses, and are more or less of a globular shape, whereas an abscess is hemispherical, resting on a stool of condensed inflammatory tissue, and has a hard rim of the same structure round it; further, cysts are usually freely movable, and, in some cases, may be reducible, *e.g.*, synovial cysts near the knee joint in cases of chronic rheumatic arthritis. In the

case of a cyst of the thyroid, situated over the common carotid, simulating an anuerism, by asking the patient to swallow, the thyroid cyst will be seen to rise and fall with the thyroid gland during deglutition, whereas an aneurism is stationary.

(4) Pulsatile Tumours of Bone :—

Aneurism.	**Pulsatile Tumour.**
1. Situated in the course of some large artery, and sharply defined.	1. May not be so. Not so well defined, and is soft, spongy and elastic.
2. Pulsation felt as a wave passing through the swelling.	2. Pulsation simultaneous at every part, though sometimes only felt at spots here and there, where large arteries enter.
3. When the main artery is compressed above the tumour, and the compression removed, the sac fills out again with two or three strong bounding beats, showing the *filling of a cavity.*	3. When so treated, the pulsation at once returns over the whole tumour, as it is only due to the *movement of blood in tubes,* not to the filling of a cavity.
4. When the artery below the tumour is compressed, the tension in the aneurism is increased.	4. Is quite unaffected by such pressure.
5. Aneurismal tumours are movable laterally, but not *in the line* of the artery.	5. Are immovable, as they grow from bone. There will probably be signs of malignant growth elsewhere, *e.g.*, in the kidney, giving rise to hæmaturia, and in the liver, causing irregular nodular enlargement.
6. When the artery above is compressed, the swelling may be partially or wholly reduced by pressure, or collapse spontaneously.	6. When the artery above is commanded, it neither collapses nor is it compressible to any great extent.
7. Bruit well marked.	7. Bruit less marked or wanting.
8. State of neighbouring bone—an aneurism eats through the bone, and one may feel the edges of the hole.	8. A pulsatile tumour growing from a bone usually expands it, so that one may be able to feel a thin shell of bone covering the tumour, and elicit "egg-shell crackling" by gentle pressure.

Progress of Aneurism.—(1) It may remain stationary. (2) Increase in size: the rate of increase depends on its position and the size of the mouth of the sac. Fusiform increase slowly; but the narrower the mouth of the sac, the greater the pressure on its walls, the more rapid its growth, and the greater the tendency to burst. This increase in size gives rise to **pressure symptoms**—*veins* are closed, causing œdema, *nerves* expanded, thinned, or irritated, *e.g.*, the superior laryngeal, causing a peculiar brassy persistent cough; the inferior, or recurrent laryngeal, causing spasmodic closure of the glottis, necessitating the performance of tracheotomy: the trunk of the sympathetic in the neck giving rise to eye symptoms: *muscles* stretched and wasted, *bones* eroded and absorbed: *œsophagus* or *trachea* pressed on, causing a difficulty in swallowing or breathing. (3) Rupture of the sac, and death from hæmorrhage, either externally or internally as into joints, pericardial or pleural cavities. (4) Spontaneous cure—(*a*) By coagulation of the blood in the sac, due to some temporary retardation of the flow, as from the growth of the aneurism causing pressure on the artery feeding it, escape of a piece of clot causing embolism beyond the aneurism, displaced clot plugging the mouth of the artery leaving the aneurism, or a clot washed down into the feeding artery from some aneurism higher up. (*b*) Suppuration and sloughing of the sac, provided the communication between the artery and the sac is closed up before the abscess bursts; if not, it may speedily cause fatal hæmorrhage. (*c*) It is believed by some Surgeons that an aneurism may be cured spontaneously by inflammation of the sac without suppuration.

In the first form of **spontaneous cure** there is gradual deposition of laminated clot, which tends to restore the resisting force of the wall of the vessel. The outer part of the clot ("*active clot*") consists of numerous layers of fibrin, and is firmly attached to the wall of the aneurism; these layers not only strengthen the part, but they tend to contract, and as they do so they cause contraction of the sac, and gradually narrow it down to the level of the lumen of the original vessel, or may even close it up entirely. In order that a clot may form, the force of the circulation must be lessened, and when the clot formation is once begun it goes on till the whole sac is full, gradually becoming denser and contracting; it thus

enables the sac to resist pressure, and stops its further growth. That part of the clot next the lumen of the vessel is soft, amorphous, and red, like red currant jelly ("*passive clot*"). In many of the cases examined this is, in all probability, only a post-mortem clot; but there is good reason for believing that it precedes the firm, laminated external clot, and is also formed in those cases where an aneurism is cured by pressure in a few hours. It is well to bear in mind, however, that unless great care be taken it is apt to be broken down and washed away, and then the apparently cured disease begins again. It is most difficult to induce coagulation in vessels near the heart, on account of the difficulty in obtaining a temporary retardation of the blood current; it is specially difficult in fusiform aneurism of the arch of the aorta.

CHAPTER II.

TREATMENT OF ANEURISM.

THE treatment of Aneurism is divided into *Medical* and *Surgical;* but in practice it is always better to combine them.

MEDICAL.

This includes—(1) **Rest in bed** in the recumbent posture, or in such a position as to impede the supply to, but to assist the return from, the aneurism; at the same time, paying special attention to the general health, giving a light, simple, unstimulating diet, but one nevertheless sufficient for the needs of the body, and avoiding all excitement, either mental or physical. (2) **Depletion** in moderation to reduce *excessive* vascular action; it also seems to increase the relative amount of fibrin in the blood. The effect on the circulation is not lasting; but this is no objection, as all that is wanted is a *temporary* lowering of the force of the circulation in order to allow the blood in the sac to *begin* to clot. This was VALSALVA's plan, only he carried it to excess, and it consequently fell into disrepute. In carrying out this method, the pulse must be carefully watched and depletion stopped at once, should there seem any tendency to syncope. (3) **Gradual starvation, especially of fluids** (TUFNELL), with the intention of reducing the total amount of blood in the body, and also the force of the heart's action. The diet is to be chiefly farinaceous, and alcohol must not be given; by some it is recommended, after coagulation has commenced, that a liberal proportion of animal food should be allowed, in order to increase the amount of fibrin in the blood. The diet recommended is something like the following:—2 oz. of bread and butter for breakfast; 2 oz. of bread and 2 oz. of meat for dinner; 2 oz. of bread and butter for supper; and a little milk-and-water (as little

as possible) sipped between times. (4) **Drugs**, such as iodide of potassium, to lower vascular tension, and, at the same time, to induce coagulation by breaking up the white cells of the blood and liberating the fibrin ferment; aconite and veratria to depress and weaken the heart's action. Acetate of lead has also been recommended. It should be borne in mind, however, that drugs without rest in bed in the recumbent posture, spare diet, avoidance of all excitement, etc., are probably of little use; and that if these conditions are properly carried out they are to a great extent superfluous.

SURGICAL.

Before performing any operation, one ought to make sure that there is no internal aneurism, and that there is an absence of widespread cardiac or vascular disease.

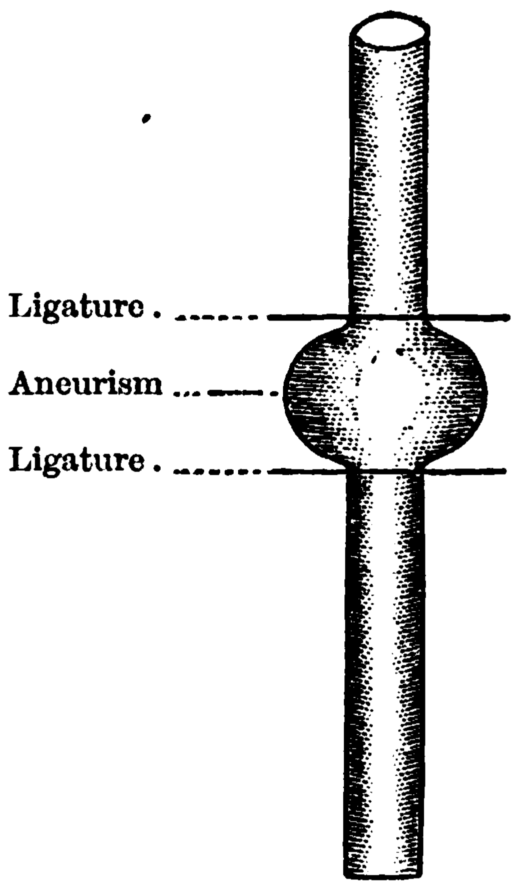
I. **LIGATURE.**—(*a*) **Method of Antyllus** (the "old operation," dating from the third century). In this method, the artery is commanded on the proximal side of the aneurism, the sac is freely exposed and opened, the clot turned out, and then, by means of a probe as guide, the arterial orifices opening into it are found, and the artery tied both above and below the aneurism (Fig. 3). In many cases it is a very dangerous and tedious operation to expose the sac, as it may be deeply placed and surrounded by important structures, *e.g.*, in the popliteal space. Further, there is a great risk of secondary hæmorrhage when the ligatures separate; besides, very often profuse suppuration of the deep trench-like wound thus made —it may be briefly characterised as ineffective, tedious, bloody, and dangerous.

In the evolution of this operation, ANTYLLUS made three mistakes:—*First*, and most serious, he tied the vessel at a part where the coats were diseased; hence, the great mortality and risk of secondary hæmorrhage. *Second*, he seemed to think that in order to cure an aneurism it was necessary to *completely* check the blood flow to and through the aneurismal sac; whereas, all that is necessary is to obtain a *temporary* decrease in the force of the blood stream. *Third*, he had erroneous views as to the value and uses of the blood clot. He thought the clot was a vicious thing,

and that it must be got rid of at all hazards before a cure could take place; whereas, it is Nature's method of cure, and must be imitated by any Surgeon who hopes to be successful in the treatment of aneurism by ligature, or any other method.

Fig. 3.

THE "OLD OPERATION."



There are still, however, certain cases in which the "old operation" is specially useful. It may be regarded as *the* operation for traumatic false aneurisms, and for this purpose it was revived by SYME, who adopted this method for the cure of a traumatic false aneurism in the axilla, probably the result of rupture of the axillary artery. Under these circumstances, however, the objections urged against the operation, as performed by ANTYLLUS, disappear. Here the coats of the artery are healthy, and the operation is nothing more or less than carrying out the universal principle—that where possible, the wounded vessel should be tied at the bleeding point. The following cases may be regarded as suitable for this method:—(1) Traumatic false aneurism of the axilla, bend of elbow, gluteal artery, etc. (2) In gluteal aneurisms, not necessarily the result of a wound, in preference to the dangerous and difficult operation of tying the internal iliac artery. Mr SYME used both methods in gluteal aneurism—one by the "old operation," the other by

ligature of the internal iliac—and both with success. (3) Where an aneurism has been opened accidentally. (4) Where the sac has burst, as an alternative to amputation of the limb. (5) In cases where the diagnosis is uncertain, as, for example, between an aneurism and a pulsating malignant growth; a diagnostic incision is made into the tumour with the view of tying the artery above and below if aneurismal, and amputating if malignant.

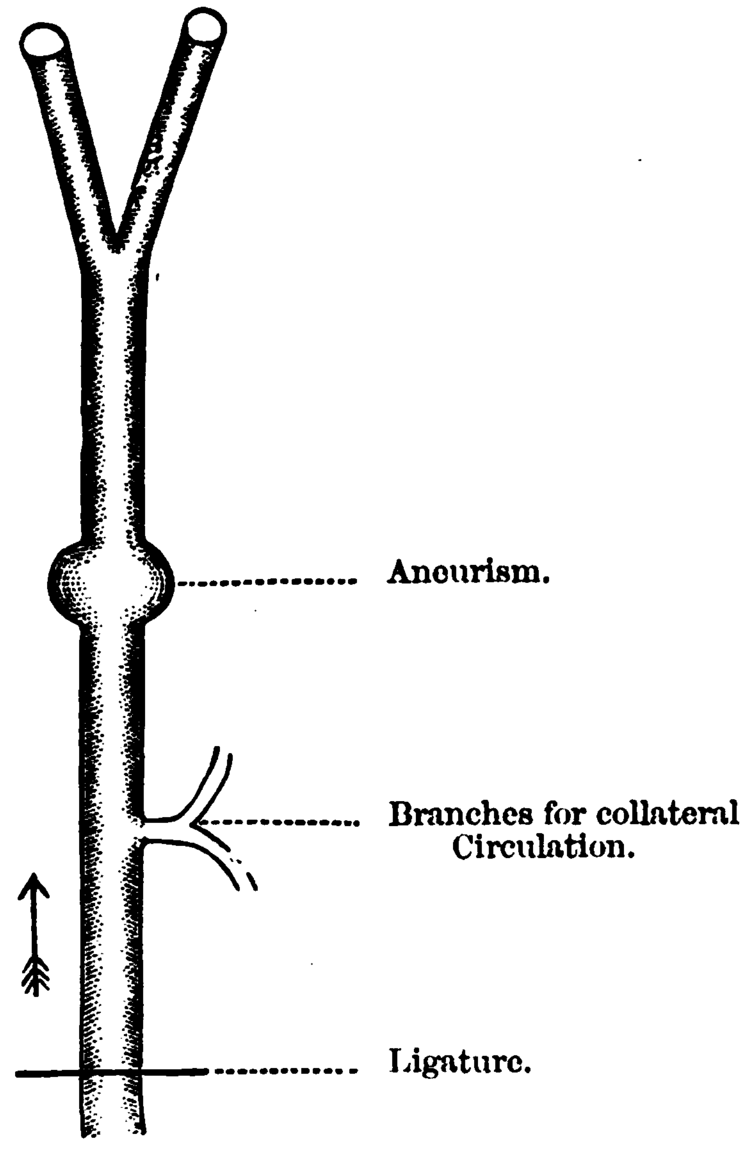
(*b*) **The Operation of Anel** (1710).—This operation only deserves a passing notice. It consists of a careful dissection down to the aneurism, and then tying the vessel close to the sac, on the proximal side only, but without laying it open as ANTYLLUS did. It is open to the same objections as those urged against the method of ANTYLLUS (when applied to spontaneous aneurism), and can hardly be looked upon as an improvement on that method:—(1) It leaves no current through the aneurism, and makes no provision for utilising the collateral circulation, and the clot formed is likely to be soft and loose. (2) A diseased part of the vessel is selected for the application of the ligature. (3) It is often difficult from the depth and complicated relations of the sac; and there is a further difficulty in securing the vessel, more especially as there is no certain guide to it, like the probe passed into the vessel through the sac in the method adopted by ANTYLLUS. I ought to mention that the "*méthode d'Anel*" occupies the same place in French Works on Surgery as the "Hunterian operation" occupies in English, German, Italian, and American Works—*i.e.*, when a French Surgeon speaks of Anel's method, he means the Hunterian operation.

(*c*) **Hunter's Method.**—More than one hundred years ago (1785), Mr HUNTER introduced a method (Fig. 4) which revolutionised the whole question of the treatment of aneurism by ligature. It was the outcome of sound reasoning, founded upon accurate observation of the methods of his predecessors, and the causes of their failures:—(1) He saw that it was necessary to select a sound part of the vessel on which to operate; he therefore tied the artery at some easily accessible point between the aneurism and the heart, but at some distance from the sac, where the coats of the vessel were healthy. (2) He believed that the clot was not an evil thing, as hitherto taught, and that it should not be interfered with as it was Nature's

method of cure; but that its formation and growth ought to be encouraged. (3) He said that to cure an aneurism it was not necessary to check the flow through it completely, but only "to take the force off the circulation" for a time. (4) He trusted to the collateral circulation to carry blood to the limb beyond the ligature, and thus prevent gangrene; but there should be no *large* vessel

Fig. 4.

HUNTER'S METHOD.



The arrow shows the direction of the blood-stream. Observe the double chain of anastomoses—one over the aneurism, the other over the ligature.

between the ligature and the aneurism. After the application of the ligature, the cure by blood clot begins, as the force of the stream is lessened, the aim being to produce a *temporary* obstruction only, and trust to the collateral circulation in the meantime.

According to Mr HOLMES the Hunterian operation is **indicated**:—(1) Whenever an active aneurism is situated upon an artery inaccessible to pressure, but which will allow a ligature to be put

round it without excessive danger, and with a sufficient space between the part tied and the tumour, *e.g.*, the iliac and carotid arteries. These vessels *might* be compressed, but the patient very often cannot bear it. (2) Where the patient from some peculiarity, constitutional or acquired, is intolerant of the more gradual methods of cure. (3) Where these methods have been tried and failed. (4) Where an aneurism has burst into one of the internal cavities of the body, *e.g.*, a popliteal aneurism into the knee joint. (5) Sometimes when the rupture has taken place subcutaneously. In some cases compression may be tried for a short time, but if it is not successful amputation or the ligature is indicated.

According to the same authority it is **contra-indicated**:—(1) In aortic and innominate aneurisms, as ligature here has always been fatal. Try medical treatment first, and only have recourse to ligature as a last resort, when medical treatment fails, or if the sac is about to burst or has burst. (2) In an artery so situated as to admit of compression, unless it has been tried and failed, or is contra-indicated. (3) In recent traumatic aneurisms, especially when caused by fracture, without a previous trial of the resources of Nature aided by rest, position, and pressure, direct or indirect. (4) In extensive disease of the heart and arterial system: in such a case digital compression is the best and safest.

(*d*) **Another method** of ligature was suggested by BRASDOR (1721–1799), although to WARDROP (1822) belongs the credit of having first performed the operation, viz., that of tying the artery on the distal side of the aneurism. It is chiefly applicable in cases of aneurism at the root of the neck, and was originally intended for aneurism at the lower part of the common carotid, or aneurisms that hold an intermediate position (as regards treatment) between the Physician and the Surgeon. It has also been used in innominate aneurisms, where a cure was attempted either by tying both its branches simultaneously, or by tying the right common carotid first, and then, if necessary, the subclavian some weeks or months later. In cases where it is judged expedient to adopt this method in innominate aneurism, the common carotid should be first secured, as it is found that in cases of natural cure this vessel is the first to be obliterated. It has further been tried in mixed innominate and aortic aneurisms, and in pure aortic.

A distinction is sometimes drawn between the methods of Brasdor and Wardrop. BRASDOR'S operation is ligature of the main trunk beyond the aneurism, *e.g.*, the common carotid in aneurism at its lower part (Fig. 5); whereas WARDROP'S operation is ligature of one or both of the main branches, *e.g.*, the common carotid, or the subclavian, or both, in innominate aneurism (Fig. 6).

Fig. 5.

BRASDOR'S METHOD.

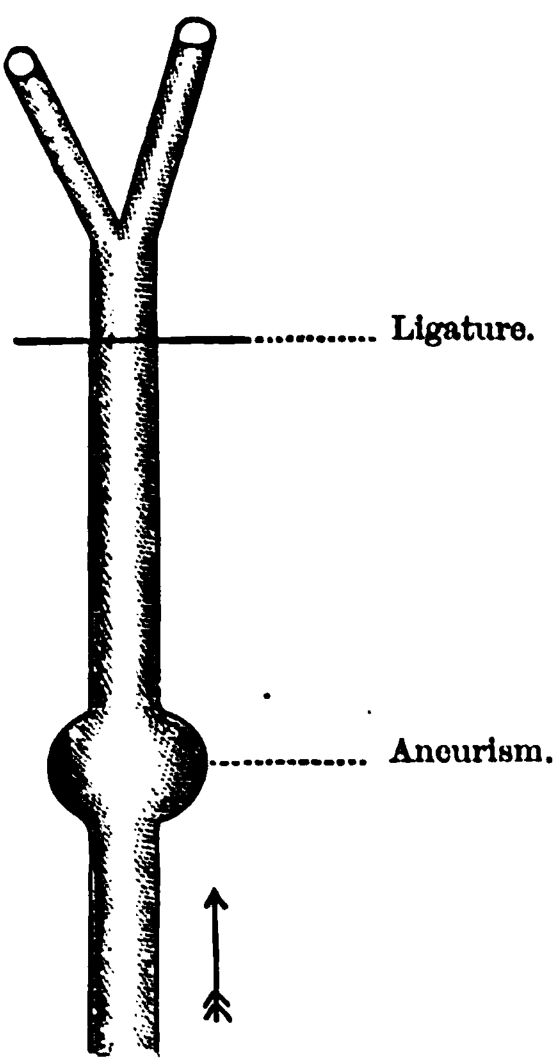
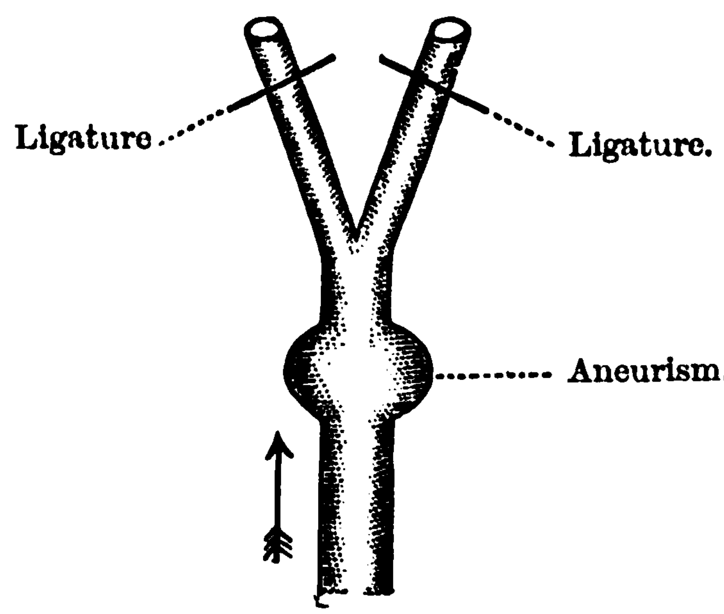


Fig. 6.

WARDROP'S METHOD.



The arrows show the direction of the blood-stream.

II. **COMPRESSION.**—This may be applied, either to the aneurism directly, or to the main artery on the proximal side of the aneurism:—(*a*) **Direct pressure** (*i.e.*, on the aneurism itself) is a method not often used, and is objectionable in many ways—(1) It is apt to cause sloughing and possible rupture of the sac. (2) If this method be worth retaining, and if it be used as a means of cure, the pressure to be efficient must, to a great extent, empty the sac of blood and keep it so, in the very nature of things; but if this is the case, then the chief factor in the formation of the blood

clot is absent, viz., blood, and it is difficult to see how a cure can be effected under these circumstances. (3) It puts the cart before the horse, as it were, or reverses the order of Nature; for it aims at causing contraction of the sac as a primary thing, whereas we have already seen, in discussing the spontaneous cure of aneurism by coagulation, that the contraction of the sac follows as a secondary result upon the contraction of the fibrin of the blood clot.

(*b*) **Indirect pressure** (*i.e.*, pressure on the main artery on the proximal side of the aneurism) may be applied in various ways —(1) **Digital,** by relays of well-trained intelligent assistants, taught how to apply a proper amount of pressure, and in the proper direction. It is, as a rule, simple, easy, painless, and rapid, and statistics of results are much better than those of ligature. Pressure is further useful in many cases, *e.g.*, in the femoral, even though the vessel may have to be ligatured afterwards, as it opens up the collateral circulation, and for this reason gangrene is less likely to follow the operation. In some cases, however, it is very painful, so that the patient must be kept under the influence of an anæsthetic. (2) **Instrumental,** as CARTE's tourniquet, or P. H. WATSON's weight-compressor for the femoral artery in the groin; SKEY's or SIGNORONI's tourniquets for the brachial artery; and LISTER's for the aorta or common iliac arteries. Whatever method be employed there must be no circular compression of the limb, and the pressure ought, if possible, to be elastic. (3) **Flexion,** (HART) may sometimes succeed in curing aneurism situated at the bend of the limb, and on the superficial aspect of the artery, *e.g.*, in the popliteal space and in the space in front of the elbow joint. The limb is bandaged in acute flexion, and the patient is kept in bed with restricted diet. This method may be used when the aneurism is—(*a*) in the flexure of a joint; (*b*) not of large size; (*c*) when the coverings of the sac are free from inflammation; (*d*) when the joint is not involved; (*e*) when the aneurism is on the superficial aspect of the circumference of the artery; (*f*) occasionally when other means, such as ligature or instrumental compression, fail. (4) **Esmarch's bandage** (REID). This combines the effects of direct pressure, and the total stoppage of the circulation. Supposing the aneurism to be in the popliteal space, we are directed to bandage the limb from the toes up to the popliteal space pretty firmly, then

pass very lightly over the sac, or leave it free altogether, as we do not wish to empty it of blood, and then tighten again as we ascend the thigh, and finally fasten it by an elastic tube. It should be applied under anæsthesia, and kept on for one or two hours; and after removal digital compression must be kept up for some time. It is *to be used*—(1) In cases where we hope to cure the aneurism at one sitting, *i.e.*, in small and recent aneurisms. (2) Where compression and flexion have failed. It is *not to be used*—(1) Where there is any danger of the sac bursting; (2) where the aneurism is large and rapidly increasing; (3) where there is serious venous obstruction; (4) where the aneurism is inflamed. The *dangers* of this method are—(1) Rupture of the sac; (2) gangrene of the limb; (3) increase of pressure thrown upon other arteries and on the heart, especially dangerous in some forms of heart disease as, for example, fatty degeneration.

III. **MANIPULATION.**—The sac is manipulated so as to break up the fibrinous clot, and part of the broken up clot is displaced, with the intention of plugging the artery on the distal side of the aneurism (Sir W. Fergusson). In the case of aneurism of the vessels at the root of the neck it is a very dangerous and difficult proceeding and has been followed by hemiplegia, from plugging of the middle cerebral artery. In the limbs it is less dangerous.

IV. **COAGULATING INJECTIONS.**—This method can only be employed in situations where the blood current can be arrested by pressure above and below the sac, say for one hour at least after the injection, and therefore it cannot be applied in cases of innominate, aortic, or subclavian aneurism. The dangers are inflammation and abscess, and occasionally embolism. It may be used after applying Esmarch's bandage, as in Dr Reid's method of compression, and then injecting neutral ferric chloride or the fibrin ferment into the sac.

V. **INTRODUCTION OF FOREIGN BODIES** into the sac, *e.g.*, fine iron wire or horse hair, through a small canula or hollow needle. This is supposed to hasten the formation of, and entangle the fibrin of the blood, in the same way that drawn blood is defibrinated by whipping it with a bundle of twigs. It has been used in some cases of aortic and subclavian aneurisms.

VI. **GALVANO-PUNCTURE** (Dr John Duncan).—This may be used in some cases of internal aneurism, or aneurism at the root of the neck where other operations are contra-indicated. At the + pole the clot is hard, small, and firm, oxygen is set free, iron salts are produced, and the fluid round the needle has an acid reaction. At the — pole the clot is soft, loose, large and frothy, hydrogen is set free, and the fluid round the electrode has an alkaline reaction, caustic potash being produced; although the clot produced is not so firm as that at the positive pole, its effect in cauterising the tissues is much more marked. Both poles may be introduced into the sac at some little distance from each other, or the + pole alone may be inserted, while the other pole is made to rest on a broad, flat, moist sponge, on some other part of the body. In this way the tissues near the — pole are not cauterised, as the broad sponge forms, as it were, a wide door through which the electricity can pass under low pressure, just like the broad copper plate which should always form the ground termination of a lightning conductor. The needles should be insulated almost to the very point. Use a weak continuous current for ten or twenty minutes at each sitting. The same precautions must be adopted as in the introduction of coagulating injections, lest it give rise to fatal embolism. The objections to its use are—(1) That it only produces a soft coagulum, which is apt to melt, and the cure is thus rendered uncertain; (2) it is liable to set up severe inflammation of the sac and its contents; (3) the needles may produce eschars at the points of their insertion, and thus give rise to secondary hæmorrhage.

In the **treatment of aneurismal varix**, operation is seldom called for, as there is no true aneurism, and the disease has but little tendency to spread. It is chiefly a dilatation of *veins*, and it rarely tends to rupture or ulcerate—except in the lower extremity where it may extend and occasionally ruptures, giving rise to fatal hæmorrhage, in the same way that varicose veins occasionally do. This condition may exist for the greater part of a life-time with but little change, especially in the upper extremity; and the rule is that if it is not advancing it should be left alone, so far as any operative measures are concerned. All that requires to be done is to give support to the distended vessels by Martin's bandage, elastic or laced stockings, etc. The different

operative measures recommended for radical cure are—(1) Indirect pressure, digital or instrumental; (2) flexion; but both these plans are probably of little use as there is no distinct sac, and therefore little tendency to the formation of a proper coagulum as in aneurism; (3) injection of coagulating fluids; (4) ligature of the artery above and below its communication with the vein. If aneurismal varix occurs within the skull, it may be necessary to resort to the Hunterian method, and ligature the common or internal carotid.

The **Treatment of a Varicose Aneurism** must be conducted on different principles. Here there is a constant tendency to increase in size, and it must not be left to take its own course as it will either become diffuse through the limb, or ulcerate and give way externally. Various methods have been proposed for its cure—(1) The "old operation," as in ordinary false aneurism answers very well, especially if it is done early enough, before the coats of the vessel have become so altered that they will not bear a ligature. Mr SYME treated ten cases in this way—"Opening the sac and applying ligatures on both sides of the aperture." Some recommend that the sac should not be opened, but simply isolate the artery and tie it above and below (ROUX, FERGUSSON). In either case the special *dangers* are—(*a*) Hæmorrhage from the part of the artery above the sac; (*b*) gangrene of the limb below the sac. (2) Injection of coagulating fluids, such as a weak solution of neutral ferric chloride, with the usual precautions; (3) compression, direct and indirect; (4) galvano-puncture; (5) expectant, *i.e.*, do nothing; (6) amputation.

The **Treatment of Cirsoid Aneurism** requires great caution as the methods usually adopted often fail directly, or though for a time apparently successful, yet relapses are very frequent, and occasionally even a fatal termination has followed operations undertaken for the relief of this condition. Undoubtedly the best method of treatment is that introduced and perfected by Dr JOHN DUNCAN of Edinburgh, viz.—electrolysis, or galvano-puncture. Dr DUNCAN, who is probably the greatest authority on the subject of electrolysis in the treatment of aneurism, nævi, etc., has used this method with remarkable and unvarying success for very many years. The cure is produced in two ways—(1) By coagulation the blood; (2) by cauterising the walls of the arteries. The

coagulant in this case is in small amount, finely divided, and in the nascent state; coagulation is principally caused by the positive pole, the cauterising action by the negative. The advantages are—(1) That it leaves no scar; (2) that the effect can be very easily graduated, for the amount of hardening can be felt as the operation proceeds. It is important not to allow the points of the needles to approach the skin too closely lest it be cauterised and produce sloughing, which will not only leave a scar, but also forms an inlet for the admission of septic organisms, which will lead, unless great care be taken, to breaking down of the blood clot. Many other measures have been tried, but, on the whole, with little success; some of these may be enumerated—(1) Compression, a very doubtful proceeding; (2) ligature of the branches passing to the affected part, usually unsuccessful, on account of the free anastomoses; also ligature of the arteries on both sides of the mass; (3) extirpation *en masse*, by knife or ligature; (4) injection of coagulating fluids, which may at one time cause sloughing and at another be absolutely without effect, and is, therefore, on the whole, unsatisfactory.

CHAPTER III.

LIGATURE OF ARTERIES IN CONTINUITY.

THE ANATOMY OF AN ARTERY.

Coats.—1. **Tunica interna,** or internal coat—(*a*) A single layer of *flattened endothelial cells* lining its lumen, which gives to it its smoothness, and serves to lessen friction; (*b*) a *sub-endothelial layer* of delicate connective tissue, with cells, especially marked in the larger arteries; (*c*) an *elastic* layer, either in the form of a longitudinal elastic network, or else as a perforated membrane (the *fenestrated membrane* of Henle). The internal coat is very easily broken across, especially in the transverse direction, and the broken edge shows a great tendency to curl inwards; this coat may be ruptured without rupture of the external coat, and when this is the case the edges curl inwards, a blood clot forms, the flow through the artery is checked, and finally, "organisation" of the clot, and complete obliteration of the vessel, takes place.

2. **Tunica media,** or middle coat, consists of bundles of non-striped muscular fibres disposed circularly round the vessel, with a certain proportion of elastic fibres. In passing from the larger to the smaller arteries the proportion (in thickness) of the muscular fibres increase in comparison with the calibre of the vessel; but in passing from the smaller to the larger the proportion of elastic tissue increases, and hence in the aorta it is very well marked. This coat is very easily torn by any force that compresses the artery transversely—such as a ligature—or that stretches the vessel longitudinally. Both the internal and middle coats are divided when a ligature is applied tightly round the artery. The *contractility* of arteries depends on the middle coat, and is most marked, therefore, in the small arteries.

3. The **Tunica adventitia**, or external coat, consists of a closely felted layer of white connective tissue, with a varying proportion of longitudinally disposed elastic fibres, which are specially seen towards the inner part of the coat, next the muscular fibres of the tunica media, in arteries of medium size. The arteries within the cavity of the cranium and spinal canal have very thin walls, chiefly due to the thinness of their external and middle coats.

The Arterial Sheath.—In most parts of the body the arteries are enclosed in a sheath of connective tissue, to which the external coat is but very loosely connected by filaments of fibrous tissue, and the sheath itself is but loosely attached to the surrounding structures. The arteries within the cranial cavity, and the first part of the aorta possess no such sheath, and this explains why aneurism of these vessels burst so very easily—coupled with the thinness of the coats of the intra-cranial vessels. Some arteries, such as the common carotids and femorals, have special sheaths *in addition* to the usual sheath, a fact which the student is perhaps apt to forget when tying these vessels for the first time.

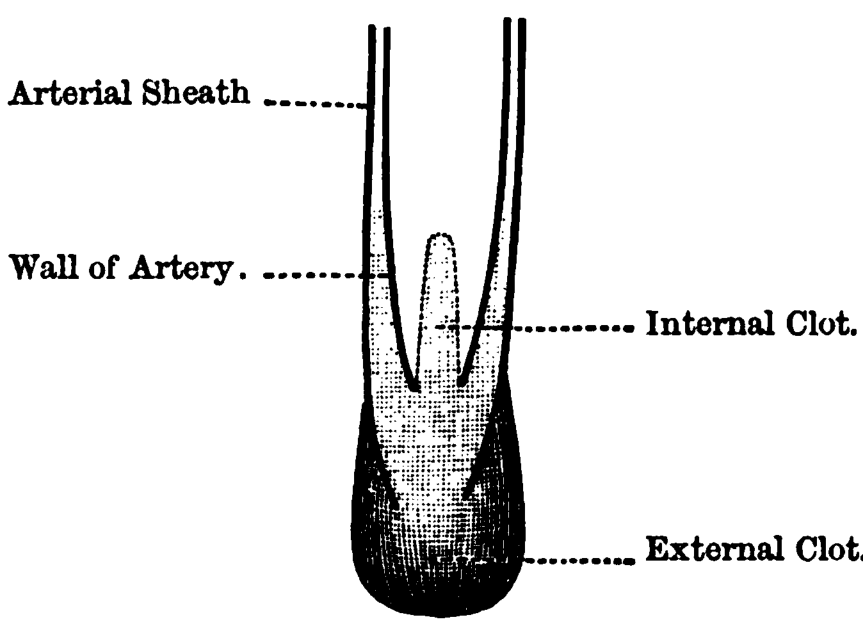
All the facts above enumerated have important bearings on the *natural arrest of hæmorrhage*, the only means at present open to many of the lower animals.

What takes place when a Medium-Sized Artery is completely cut across?—(1) The artery *contracts*, because of the circular disposition of the muscular fibres, under the stimulus of the knife. (2) It *retracts* within its sheath from the elasticity of the longitudinally disposed elastic fibres in its various coats, and, in some cases, from the presence of longitudinal contractile fibre-cells. This retraction is permitted on account of the loose connection between the tunica adventitia and the sheath. (3) The sheath being now empty for a little way, falls together or *collapses*, and this leads to the formation of (4) the "external" clot, which temporarily seals the vessel. This collapse of the sheath is permitted because of the loose connection between it and the surrounding tissues. In many cases of severe hæmorrhage, which would not otherwise cease, cardiac syncope occurs, and this gives time for the formation of an external clot which seals the vessel for the time being. There is a great risk, however, unless the vessel is otherwise secured, that when the

heart regains its vigour, the clot will be forced out, giving rise to "reactionary hæmorrhage." If this does not take place, then (5) the "internal clot" is formed, which is pyramidal in shape, and extends up the bore of the artery for a short distance. The internal clot *(bouchon)*, and that entangled in the sheath *(couvercle)*, together with the clot outside all round the severed end of the artery, has been likened, by Professor Gross, to a glass stopper fitted into a decanter (Fig. 7). Finally, the whole organises both inside and outside the artery, and also in the tissues around, and thus the perfect sealing is completed.

Fig. 7.

SPONTANEOUS ARREST OF HÆMORRHAGE.



The Result of Partial Division.—(Fig. 8).—In this case the vessel can neither contract nor retract perfectly, and the *attempts* at contraction only serve to open up the wound transversely, while

Fig. 8.

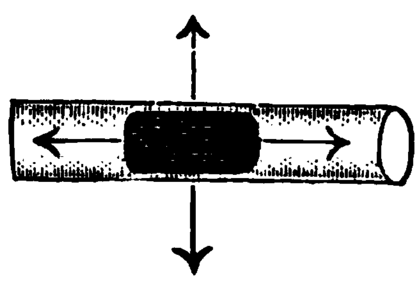
WOUNDED ARTERY.

the attempts at retraction open it up longitudinally, so that the vessel, even though small, goes on bleeding, and may even lead to a fatal termination (Fig. 9). Here, therefore, the means intended

by Nature to be unto life are found to be unto death, because they are perverted; the proper treatment for such a case is to sever the vessel completely.

Fig. 9.

WOUNDED ARTERY.



To show how the attempts at contraction and retraction open up the wound.

The Effect of Previous Chronic Inflammation.—The effect of this is—(1) To cause adhesion between the sheath and the tissues around; and (2) to cause adhesion between the outer coat of the artery and the sheath; hence, therefore, the vessel can neither contract nor retract, nor could the sheath collapse even if the vessel did retract. The result is two-fold—the bleeding is very free when operating through such tissues, and is exceedingly difficult to check, as the vessels to be tied are exceedingly numerous, and cannot be caught by the forceps in the usual way, as the coats are so softened and brittle that they break down. In this case it is often necessary to include a portion of the surrounding textures with the artery in the noose of the ligature, and this is best accomplished either by means of the old tenaculum, or else by a curved needle, threaded with catgut or fine carbolised silk.

In cases of machinery accidents, the absence of bleeding is due to a different cause; in such cases the vessels are twisted, and the inner and middle coats retract and turn inwards into a kind of valve, which effectually prevents hæmorrhage, while the outer coat is drawn out into a fine point. In like manner, the much despised and maligned cat secures the umbilical vessels of her numerous progeny, by combined chewing and tearing; in this way also, the old-style farmer controls the bleeding when castrating certain domestic animals, for, after having cut through the tunics of the testicle, he seizes that organ between his teeth and *tears* it out.

The Vessels and Nerves of Arteries.—The *vasa vasorum* are distributed to the *outer* coat of the artery; they are chiefly found

in connection with the sheath of the vessel which they perforate, and then divide into smaller branches between the sheath and the vessel, before ending in the outer coat. The *nerves* form fine plexuses in which minute ganglia are sometimes found; they penetrate as far as the middle coat, to the muscular tissue of which they are chiefly distributed.

In *arterial* hæmorrhage the blood is bright red, forced out in a jet, and *per saltum*, and pressure on the proximal side retards or stops the flow; but if the patient be inhaling ether or nitrous oxide gas the blood will be dark, and if the blood flow along a narrow sinuous wound the jetting character will be lost.

In *venous* hæmorrhage there is a rapid flow of purple or black blood in a continuous stream, and pressure on the distal side retards; but if the blood be exposed for a short time to the air it rapidly becomes red. Capillary hæmorrhage is recognised by an oozing of bright blood from the whole *surface* of the wound, and not from special points.

MATERIAL OF LIGATURE.

For a long time a single thread of **strong waxed silk** was the substance used. It was "waxed" to make it less slippery, and therefore more easily tied, to prevent the knot slipping after it was tied, and, lastly, and most important, to make it non-absorbent. Usually one end of the ligature was cut close to the knot, and the other end left hanging out at the corner of the wound, and fixed there by a small piece of plaster; at the end of ten days or a fortnight, or more, as the case might be (depending on the size of the artery tied), when the healing process was completed, the ligature was pulled away. The security of the vessel was first ascertained by gently twirling the thread between the finger and thumb, when a yielding sensation indicated that the process was complete, and that the ligature might be safely removed without the risk of secondary hæmorrhage. Sometimes both ends of the silk ligature were cut short, and, in rare instances, it became encapsuled and gave no further trouble.

The chief **objections** to the silk ligature are—(1) It is a foreign body in the wound; and (2) it separates by a process of ulceration or sloughing: a ring of granulations form on each side of the noose

and cut it off in the same way that the "line of demarcation" is formed in gangrene, and, when the separation is complete, the portion of the vessel included in the noose is brought away with the ligature as a small slough. For both these reasons the silk ligature is opposed to primary union, and may lead to complete or partial failure of the "organisation" of the clot, and the other processes necessary for the permanent sealing of the ligatured artery. It is true that in favourable cases the lymph and clot organise, and the divided internal and middle coats are blended together by firm fibrous union before the external coat is ulcerated through, and in this case there is no danger of secondary hæmorrhage. In other cases, however, the ulcerative process extends faster than the healing process, and involves the clot, which then breaks down, and there is thus a complete or partial failure of the organising process, followed by secondary hæmorrhage when the ligature separates. Hence, in using the silk ligature there was always an uncomfortable feeling of uncertainty as to the final result, which only disappeared when the ligature had separated and the wound healed. Many operators, however, still use the silk ligature in securing the main artery of a limb, as in amputations; the silk is first boiled in a 1 in 20 solution of carbolic acid and kept in a solution of the same till required. This is known as **carbolised silk,** and as thus prepared is non-irritating, and either becomes encapsuled or ultimately absorbed. In septic cases, however, it is probably better to use non-absorbent material, as horse-hair, silver wire, or silkworm gut.

Next came the **catgut ligature,** introduced by Lister, and for a time seemed all that could be desired; but by and by it was put aside because it sometimes disappeared before the vessel was perfectly sealed, and secondary hæmorrhage was the result, or the knot slipped, and, further, if the wound became septic so did the ligature, and again the result was hæmorrhage. It has, however, been again revived, and is now used, but only after special preparation. At first it was prepared by being soaked for some months in carbolic acid, and the longer it was soaked the better it became; but it was found inconvenient to use a method of preparation that extended over such a lengthened period, hence the process now adopted is to soak it in a weak solution of chromic and carbolic

acids for a couple of days, after which it is removed, stretched, and dried, and preserved in carbolic oil ready for use as required. The catgut is gradually absorbed, as the process of healing is completed, by the white blood corpuscles or the granulations, and its disappearance is not accompanied by ulceration. In cases, however, of septic wounds catgut should not be used; it should be remembered, too, that catgut itself may be septic, and be the means of inducing septic processes in the wound.

Other materials have also been used with success, such as the **middle coat of the aorta** of the ox, cut into thin strips, and stretched to deprive it of excessive elasticity; it is kept in carbolised gauze, and before use it is steeped in carbolic oil to render it pliable. The **small tendons** from the tail of the kangaroo are used for a similar purpose, and have the advantage of not requiring any previous preparation. In using the ox aorta ligature and the kangaroo tendons, the artery is compressed very gently and tied with a strong knot. This method is said to be specially applicable in cases where there is a serious risk of secondary hæmorrhage, *e.g.*, near large branches, as in tying the first part of the subclavian, as the internal and middle coats are not divided unless the ligature be drawn very tight, and, further, it lasts much longer than even chromic acid catgut, and is therefore to be specially recommended in circumstances when, for special reasons, the artery must be tied at a place where its coats are diseased.

SPECIAL POINTS IN REFERENCE TO LIGATURE.

The chief points to be attended to in the ligature of arteries are the following:—

1. To select a **proper point for the application** of the ligature. (*a*) It must not be too near the aneurism, because there the coats of the vessel are diseased; (*b*) it must not be too far away from the aneurism, for then the collateral circulation will be too quickly re-established through the sac and prevent the formation of a proper clot; (*c*) it must not be too near a large branch, for then the rush of blood would prevent coagulation at the point of ligature, and the other processes necessary for the organisation of the clot, and would ultimately give rise to secondary hæmorrhage when the ligature separated.

2. To have a thorough knowledge of the **general course and relations** of the vessel, the more common abnormalities, as well as the recognised superficial and deep guides, in order to be able to mark out the vessel's course on the surface of the body; in short, the limb or other part being operated upon ought to be *transparent* to the Surgeon.

3. To make a *free* incision through the skin, and an equally **free dissection down to the sheath** of the artery, so as to lessen the depth of the wound as much as possible. Do not look for the artery in the first instance, but search for the various "rallying points" one after the other, and the vessel will be reached in due time. The integument is to be gently stretched, without displacement, by the fingers of the left hand, and all large superficial veins avoided in making the first incision; the position of any large superficial vein is best brought out by arresting the flow through it by pressure on the cardiac side, *e.g.*, the external jugular by pressing at the root of the neck, and the long saphenous by pressing a little below Poupart's ligament. A sharp scalpel should be used, and its point made to enter and leave perpendicularly to the surface to avoid "tailing." Twist or tie all bleeding vessels as you proceed, and above all things never hurry, but cut through layer after layer of the tissues covering the vessel, to the full extent of the original incision, in a calm and deliberate manner, carefully examining every layer with the eye and finger before cutting it; but at the same time avoid *lateral dissections* as far as possible.

4. Make a **very limited opening in the sheath.** Having cleared the sheath carefully from the structures covering it by means of the finger or director, take hold of it with the forceps and pinch up a small piece into the form of a cone, off the artery, and then cut into this cone by means of the scalpel, held flatwise, with its edge *away from* the vessel, and on a plane just superficial to it. Take hold of that side of the opening in the sheath furthest from you by a pair of Péan's, or the ordinary toothed forceps, in order not to lose sight of the opening, and take hold of the other edge with your dissecting forceps and clear a portion of the artery just sufficient to pass the point of the aneurism needle below the vessel. The clearing of the vessel well is one of the most important points of the operation. It should be cleared by means of the scalpel and

forceps till the white external coat of the vessel comes into view, the back of the knife in the meantime being directed towards the artery; the opening in the sheath should be about one quarter of an inch above, and one sixth of an inch below. Too free separation of the sheath from the artery will endanger the vitality of the latter by the destruction of the vasa vasorum, which pass from the sheath to the coats of the artery; but, on the other hand, a small channel *must be cleared thoroughly* in order to pass the armed aneurism needle *easily*.

5. **On no account lift the vessel** from its bed, as to do so would endanger its vitality, by destroying the delicate vasa vasorum, and pave the way for sloughing of the vessel and secondary hæmorrhage. The aneurism needle, with or without the ligature, is passed through the aperture in the sheath and gently insinuated round the vessel till its point is just visible on the other side, and then the ligature is seized and drawn out by a pair of forceps, while the needle itself is gently withdrawn. The handle of the needle must on no account be depressed, as this would raise the vessel from its bed; also great care must be taken not to slide the ligature up and down the artery, as in both cases the vasa vasorum would be destroyed. The *vasa vasorum* run for a little way in the sheath before entering the wall of the artery, and this probably explains why it is that in secondary hæmorrhage the blood most frequently comes from the distal side of the ligature; and the better nutritive supply on the proximal side, explains why that end of the vessel is more firmly occluded than the distal end. The needle should be passed from the side where the chief danger exists, and this, in large arteries, is usually the vein—a noteworthy exception to this rule is seen in the case of the third part of the subclavian. In cases where the artery is accompanied by two veins the needle should be passed from the side on which the nerve is placed. Many text-books recommend that the needle should be passed unarmed, except in the case of deep-seated arteries, as the iliacs; it certainly passes more easily unarmed, but I do not think the question is one of great importance.

6. Before finishing this part of the operation, **compress the artery** between the finger and the curve of the aneurism needle, *in order to make sure* that no other structure, such as a nerve, for

example, is included in the ligature as well as the artery, and note at the same time if this pressure stops the pulsation in the artery or sac beyond—this precaution is specially necessary in tying the subclavian in its third part. Carefully avoid in any way injuring the veins.

7. The ligature must be tied transversely round the artery, because if placed obliquely the knot tends to slacken. In tying press down the knot with the tips of the forefingers, as over pulleys, and draw the noose moderately tight so as to divide the internal and middle coats of the vessel, and then tie again forming a reef knot, or what is probably better, use the double hitch or surgical knot, *i.e.*, put the first loop twice through before tightening. After tying a silk ligature one end is cut off close to the knot on the vessel, while the other is left hanging out of the wound; if catgut be used, then both ends are cut off close to the knot.

Methods of Holding the Knife.—(*a*) *Like a Pen:* the position of "lightness and precision," the method often adopted in ligature of arteries, where the incision required is not of great extent, the hand resting on the neighbouring parts. (*b*) *Like the Bow of a Violin:* the position of "nicety and precaution." This method gives a greater range of motion, but the hand must be firm and steady, as it cannot be "rested." (*c*) *Like an ordinary Dinner-knife:* the position of "firmness and strength," and used where greater force is required. In opening fasciæ and aponeuroses upon a director, the knife is used with reversed blade.

Position of the Patient.—The patient at first is placed in such a position as to render prominent the anatomical guides to the artery—usually therefore one of extension—but afterwards, as the artery is approached, the parts must be relaxed by flexion, so as to give the operator more room.

Before concluding this section, I ought to mention that many Surgeons adopt a slightly different method of procedure from the one above described:—

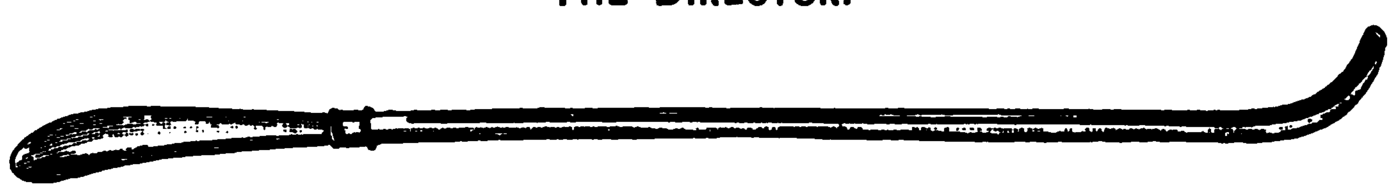
1. The knife is held like a pen, while the hand rests on the neighbouring parts; it is made to enter the skin with this inclination, but is gradually made to approach the perpendicular as the *incision is completed.*

2. A steel director is much used: upon this deep fasciæ and aponeuroses are divided, and it is further to be used to separate muscular interspaces, and also to separate the artery from its sheath.

3. When the sheath is opened the knife is to be laid aside and the vessel cleared by the director and forceps alone. I may here say that if a director is to be used at all to clear the vessel, the most convenient form to employ is, not the straight steel director, but the ordinary German silver one, with a short curve at the lower end, the concavity of the curve being turned towards the grooved side (Fig. 10).

Fig. 10.

THE DIRECTOR.



4. The aneurism needle is to be passed unthreaded, and any tissue preventing the easy passage of its point round the artery, is to be scratched through with the thumb nail, or the scalpel cutting against the needle with the edge away from the artery.

Should the director I have figured be used, the best way to pass it is as follows:—A small opening having been made in the sheath, the external edge of the opening is to be grasped by a pair of ordinary catch forceps (Péan's forceps will do equally well), and given to an assistant, while the operator seizes the edge next himself with the dissecting forceps; gentle traction should then be made, and in this way, the posterior part of the sheath is gently stretched between the two pairs of forceps, and is thus steadied and prevented from rolling and doubling before the point of the director, the curved part of which then slips round the artery very readily. When the point appears at the other side, the edges of the opening in the sheath are let go, the Surgeon takes the aneurism needle and lays its point into the groove on the director, withdraws the director, and at the same moment carries the needle round the artery, so that as the director retreats it carries the needle with it. The needle is then threaded and withdrawn, and the ligature tied in the ordinary way.

COMPLICATIONS AND THEIR TREATMENT.

The chief **unfavourable results** that may ensue from this operation are:—(1) *Continuance or return of the pulsation* in the sac from misapplied or badly applied ligature, *e.g.*, placed obliquely instead of transversely, or from the presence of a *vas aberrans*, or from a too free collateral circulation, or when the ligature is applied at too great a distance from the sac. (2) *Formation of another aneurism* at the next weakest point of the vascular system. (3) *Gangrene* of the limb, from the third to the tenth day, due to the too tardy establishment of an adequate collateral circulation to keep up the vitality of the limb beyond the aneurism, or from injury to the vein. (4) *Suppuration* and sloughing of the sac. (5) *Hæmorrhage* when the ligature separates, from disease of the coats, or sloughing of the included portion of the vessel before the ends have become permanently sealed by the reparative process; this may be caused by lifting the vessel from its bed or sliding the ligature up and down, and in this way destroying its nutritive supply.

The **treatment** after the operation should be mainly directed to avert the tendency to gangrene. The limb should be surrounded by a thick layer of carded wool to keep up its temperature, and elevated to assist the venous return. The diet should be moderately nourishing and easily digested, with the judicious use of opium, which not only soothes the patient, but also dilates the small arteries and capillaries, and thus assists the establishment of the collateral circulation. On no account should artificial warmth, in the form of hot bottles, be applied *to* the limb, as this would only hasten the gangrene.

CHAPTER IV.

ANEURISM OF THE THORACIC AORTA.

ALTHOUGH this part of the aorta, for obvious reasons, is never tied during life, still aneurism in some part of its course in the thorax is, unfortunately, the most common of all forms of aneurism, and a knowledge of its relations to the surrounding structures is absolutely essential in order to interpret the leading symptoms. To point out these relations, therefore, and the chief untoward effects likely to be produced when these relations are disturbed by disease, will form a fitting introduction to the subject of ligature of special arteries. There are many reasons why aneurism should be so common here:—(1) It is much curved; (2) it gives off large branches; (3) the first part of the arch has no sheath, and the rest of the thoracic aorta is but feebly supported; (4) the jet of blood driven against its upper wall at each systole is apt to bulge the coats at that point; (5) sudden variations in pressure according to the state of the heart; (6) the aspiration of the thorax affects it, for as the chest enlarges the vessel tends to expand.

FIRST, OR ASCENDING PART.—It *arises* from the base of the left ventricle at the level of the **sixth dorsal vertebra** behind, and the **third left costal cartilage** in front. From this point it passes upwards, to the right, and forwards, and touches the sternum at the upper border of the **second right costal cartilage.** This part of the arch is contained in the fibrous pericardium, and is surrounded by a tube of the serous pericardium common to it and the pulmonary artery before its bifurcation; this depends on the fact that both vessels are developed from the *bulbus arteriosus (truncus communis arteriosus)* of the embryo. **Relations.**—In *front*—Pulmonary artery, pericardium, right auricular appendix,

and chest wall. *Behind*—Right pulmonary vessels and right bronchus. To its *right side*—Superior vena cava and right auricular appendix. *Left side*—Pulmonary artery.

SECOND, OR TRANSVERSE PART.—This part extends from the **second right costal cartilage,** passing transversely to the left, and backwards, to reach the left side of the body of the **fourth dorsal vertebra.** **Relations.**—It lies under cover of the left pleura, near its termination. *Above*—There is the left innominate vein, and the three large branches of the arch—(*a*) The innominate artery; (*b*) left common carotid; (*c*) left subclavian. *In front*—It is overlapped by the left pleura and lung, and then from left to right by the following nerves—(*a*) Left vagus giving off its recurrent laryngeal branch; (*b*) cardiac nerves to the superficial cardiac plexus (left superior cervical of the sympathetic, and inferior cardiac of left vagus); (*c*) left phrenic, crossing in front of the other nerves. *Below*—Pulmonary artery bifurcating, the obliterated ductus arteriosus connecting its left division with the aorta, superficial cardiac plexus, left recurrent laryngeal nerve and the left bronchus. *Behind*—Bifurcation of the trachea, deep cardiac plexus, left recurrent laryngeal nerve, œsophagus and thoracic duct.

THIRD, OR DESCENDING PART.—Extends from the lower border of the left side of the body of the **fourth dorsal vertebra,** to the lower border of the left side of the body of the **fifth dorsal vertebra.** **Relations.**—*In front,* the left pleura and lung, and partly also the root of the lung. It lies against the vertebral column, and to its *right side,* but on a plane anterior to it, we have the œsophagus and thoracic duct, while on the *left side* it is covered by the pleura and lung.

SYMPTOMS AND DIAGNOSIS.

The **general** means at our disposal for the diagnosis of aneurism of the aorta in the thorax, as well as its probable position, have been divided into direct and indirect. Fortunately this differential diagnosis as to the part affected, guides the special prognosis more than it modifies the treatment. The **direct** means of diagnosis include inspection, palpation, percussion, and auscultation.

Inspection may discover a bulging which may or may not pulsate, or heave. *Palpation* may show that the pulsation is expansile and not a mere upheaval, and may also detect thrills. *Percussion* indicates an increased area of dulness, and also the shape of that area, and its probable relation to the heart and great vessels. By *Auscultation* we may hear the normal cardiac sounds very clearly in the sac, though they may be less clear between the sac and the heart; and valvular murmurs may also be well heard, being transmitted by the blood current. At times also local murmurs, produced in the sac, usually systolic in time, are heard. A very common effect of aneurism of the arch is to produce accentuation of the second sound in the aortic area.

The **indirect** evidences are derived from the **pressure effects** on surrounding structures.

1. The **Œsophagus**, causing difficulty in swallowing, especially of solids; on auscultating over the course of the œsophagus behind, delay in the transmission of the bolus may be detected. It may also be displaced to one side.

2. **Thoracic Duct**, producing rapid emaciation, anæmia, and sometimes ascites, the fluid poured out resembling chyle. On account of the pressure on the duct, the lymph and chyle that it normally conveys from the intestines to the blood is lost to the body, so far as nutrition is concerned, and hence the emaciation, on account of this great loss of fat, which may be discovered in the stools, causing fatty diarrhœa.

3. **Heart and Blood Vessels.**—The heart may be displaced and its movements impeded, causing palpitation and other signs of heart disease; the arteries are usually imperfectly filled, and therefore show diminished tension, and there is also delay in the transmission of the pulse wave. This accounts for the difference in strength between the two radials, and the want of synchronism usually observed in these cases; these changes are best shown by the sphygmograph. The veins are over-filled, hence the œdema.

4. **Respiratory Organs.**—When the trachea is pressed on, the patient has a feeling as if he were being throttled, the respiration is noisy, and on auscultation a leopard-like growl may be heard; this feeling is increased by exertion and excitement—this is an important aid in the diagnosis of aneurism from ordinary tumours.

There is a peculiar harsh, brassy cough, like the cry of a gander, but no expectoration, unless there is ulceration present, when there will probably also be hæmoptysis; the respiratory murmur will be feeble in both lungs. If only one bronchus is pressed upon, the symptoms will be somewhat similar but confined to one side; there is also very frequently a harsh snoring or wheezing heard over the part pressed on, from the alteration produced in the size of the tube. There are no crepitations, nor is the vocal resonance increased, and therefore it differs from pneumonia. When the *Pulmonary Artery* is pressed on, the symptoms resemble those of asthma. From this, however, it may be distinguished by the fact that it is bad day and night, that atmospheric conditions do not specially affect it, and that it is relieved by the patient assuming a certain position.

5. **Nerves.**—When nerves are affected we must distinguish two stages—(*a*) A stage of *irritation*, motor or sensory; and (*b*) the stage of *paralysis*. In *sensory* nerves there is at first severe shooting pains, spreading in various directions along the nerve and its communications; this may be followed by complete or partial anæsthesia. In *motor* nerves we first have spasmodic contraction of the muscles they supply, followed, sooner or later, by paralysis. As examples of the above, we have pressure on the *cardiac* nerves producing severe anginous pains; the *phrenic*, first irritated, causing hiccough, later paralysed; *recurrent laryngeal*, causing alteration of voice and dyspnœa from spasm of the muscles of the larynx during the stage of irritation, later aphonia from paralysis of the same muscles; on the *vagus*, causing severe anginous pains, irregular action of the heart, nausea and retching, asthmatic dyspnœa, and probably inflammation of the lungs; the *sympathetic*, during the stage of irritation causing dilatation of the pupil, with pallor and coldness of that side of the head and face, from vaso-motor stimulation, but later, when the nerve is paralysed, contraction of the pupil, with redness and increased heat of that side of the head and face, from vaso-motor paralysis. It may perhaps be as well, at this stage, to point out that it is only in cases of dyspnœa from spasm of the muscles of the larynx, that tracheotomy is followed by any benefit; if it arises from pressure on the trachea or bronchi by the aneurism, it is of no use. To diagnose the two conditions

the laryngoscope should be used: then, if it be due to pressure on the recurrent laryngeal nerve, the abductor will be paralysed, and the cord of that side will be found in the "cadaveric position," but if due to direct pressure on the air tubes, the cords will be widely abducted during inspiration. Further, in *laryngeal dyspnœa*, the larynx itself moves energetically with respiration, while in *tracheal dyspnœa* it is stationary. Note, that enlarged bronchial glands may cause spasm of the glottis, as from tubercular, cancerous, or lymphadenomatous affections.

6. **Bones** are eroded and absorbed, and during the absorption there is severe pain, which is sometimes mistaken for rheumatism. The pain in the earlier stage is usually lancinating, intermittent, and neuralgic in character, and is probably due to pressure on the sympathetic or spinal nerves; it radiates in various directions—left side of head and face, left arm, etc. Later, the pain is more of a burning or boring character, and seems to depend on the absorption of the bony tissue and other compact structures. In the case of the vertebræ it may cause curvature of the spine, and lead to compression of the spinal cord, at first producing symptoms of motor and sensory irritation, gradually passing into paralysis of all the body below the level of the lesion. In attempting to distinguish between solid mediastinal tumours and aneurism, the following points should be kept in mind:—(1) In the case of aneurism the symptoms vary, being worse after excitement or exertion. (2) A solid tumour may have a communicated impulse, but this impulse is never expansile. (3) Solid tumours neither reproduce the heart-sounds, nor do they give rise to sounds of their own. (4) In solid tumours it is very rare to find any difference in the pulses on the two sides of the body.

DIFFERENTIAL DIAGNOSIS AS TO THE PART AFFECTED.

Ascending Part.—On the anterior aspect it may appear as a pulsating tumour between the intercostal spaces on the right side of the sternum; there is increased dullness on percussion to the right of the sternum, and, as the aneurism increases in size, it may compress any or all of the structures in relation to it. In this

part of the arch the aneurism rarely reaches a large size before it bursts into the pericardium, since this part has no fibrous sheath like other arteries (those of the brain excepted), causing sudden death by by filling it and stopping the heart. It may also open into the superior vena cava, giving rise to a continuous murmur of a peculiar character. Should the aneurism be situated on the posterior aspect, it may give rise to no symptoms except *accentuation of the second sound* in the aortic area, and delay of the radial pulse.

Transverse Part.—When on the convex aspect it tends to pass to the right side of the sternum, or it may present at or above the manubrium sterni in the middle line; the cardiac plexus is frequently pressed on, causing *angina-like pains;* and the *voice is altered* from pressure on the left recurrent laryngeal nerve, simulating laryngitis, or, more serious, laryngeal disease. *Dyspnœa* is an urgent symptom from pressure upon the trachea, bronchi, pulmonary veins, or left recurrent laryngeal nerve; it may also produce *cough* and hæmoptysis, and ultimately burst into the trachea, producing fatal hæmorrhage. It may further involve the thoracic duct or œsophagus, and cerebral disturbances are common from interruption of the circulation through the carotid arteries; and when the innominate or left subclavian are involved, there will be weakness and delay of the pulse at one or other wrists. It is very difficult to differentiate aneurism of this part from aneurism of one of the arteries at the root of the neck; but in the case of aortic aneurism the tumour is seen to have no defined lower boundary on percussion. There is usually well-marked œdema, from pressure on the neighbouring veins.

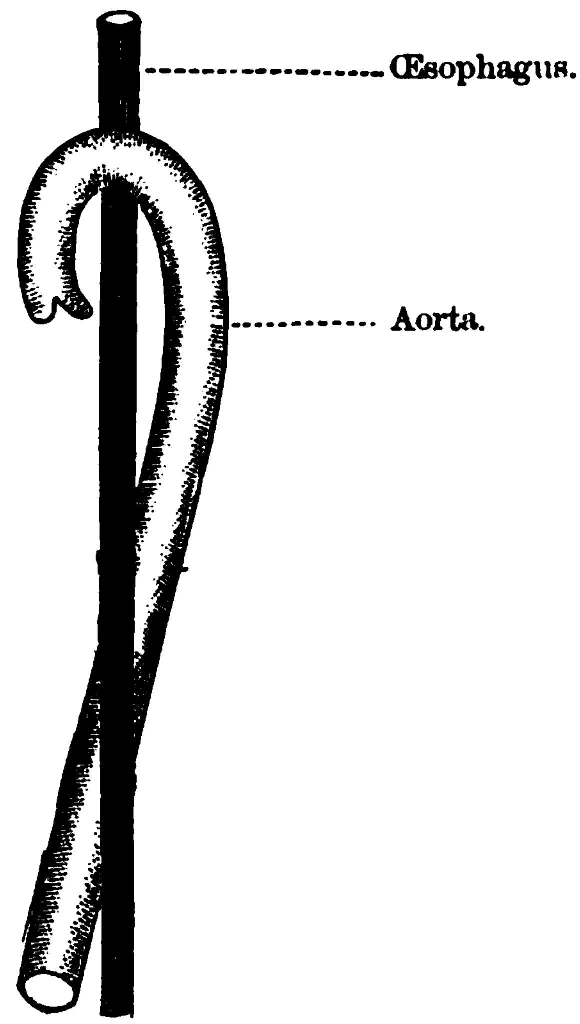
Descending Part.—The symptoms are obscure. There is dullness on percussion over the back or front, in both cases to the left of the median line, and later the appearance of a pulsating tumour. There is marked erosion or absorption of the vertebræ, giving rise to severe pain, referred either to back or chest, and radiating round the intercostal nerves of the left side; pressure on the left bronchus or trachea, and displacement of the left lung; pressure on the œsophagus causing dysphagia, probably the most distressing symptom of aneurism in this region. To these may be added the symptoms of pressure on the thoracic duct and veins of the chest-wall together with delay of the femoral pulse.

THE DESCENDING THORACIC AORTA.

This part of the aorta is the direct continuation of the **aortic arch**, and extends from the lower part of the left side of the **body** of the **fifth dorsal vertebra** (TURNER), lower border of the **fourth** (GRAY) to the anterior aspect of the **last dorsal vertebra, where it** leaves the thorax by passing through the aortic opening of **the** diaphragm. **Relations.**—*Behind,* it lies against the **vertebral** column following the dorsal curve; it also crosses the vena **azygos** minor inferior, and sometimes the vena azygos minor **superior.**

Fig. 11.

ŒSOPHAGUS AND THORACIC AORTA.



In front, it is covered by the pericardium, crossed transversely by the root of the left lung, and very obliquely by the œsophagus. To the *right side,* we find the œsophagus (at its upper part), vena azygos major, and thoracic duct. To the *left side,* the œsophagus (at its lower part), pleura, and left lung. The relation that the **œsophagus** bears to the different parts of the aorta in the thorax is worthy of special note (Fig. 11). It lies behind the transverse part of the

arch, to the right of the descending part; to the right, then in front, and, lastly, to the left side of the descending thoracic aorta. These relations are to be specially remembered in cases of real or supposed stricture of the œsophagus, for both in stricture and aneurism there is marked dysphagia, and it is of the utmost importance to find out on what this depends. Occasionally in aneurism the patient has been treated for stricture of the œsophagus by the introduction of bougies, with the unfortunate and fatal result of perforation of the sac by the point of the instrument.

NOTE.—(1) The aorta in this part of its course, it will be observed, is covered by the left costal pleura; aneurism therefore in this part of the vessel is very apt to burst into the left pleural cavity by a large rent, giving rise to sudden and fatal hæmorrhage (when an aneurism opens on a *mucous* surface, the rent is seldom large, and death rarely so sudden as when it opens into a serous cavity). (2) The spinal column is pressed upon, the vertebræ are absorbed, and the cord may suffer, causing paralysis of the lower extremities. (3) The root of the left lung passes in front of the vessel, and in the root the bronchus is the most posterior structure; hence this tube is narrowed, the lung therefore is imperfectly filled, and peculiar respiratory sounds are heard on auscultation. (4) The heart enveloped by the pericardium is also in front, and the growth of the aneurism impedes the movements of that viscus, and the disturbance thus caused may simulate heart disease. (5) There is dysphagia from pressure on the œsophagus. (See above, p. 40, and Fig. 11.) (6) The thoracic duct is pressed on and may be obliterated, when there will be marked emaciation from the lymph and chyle lost to nutrition.

Although the aorta in this part of its course is not tied by the Surgeon, yet, curiously enough, Nature herself can perform even this operation with success; for it is by no means uncommon to find the aorta obliterated just beyond the ductus arteriosus, or at the junction of the arch with the descending aorta, and yet the patient has survived. This is very interesting from a surgical point of view, as it shows the resources of the collateral circulation, and that it is possible to live, so far as that at least is concerned, even when the aorta is tied. According to Mr SYDNEY JONES, the principal communications by which the circulation was carried on

were—(1) The internal mammary anastomosing with the intercostal arteries, with the phrenic of the abdominal aorta, by means of the musculo-phrenic, and comes nervi phrenici, and largely with the deep epigastric. (2) The superior intercostal, anastomosing anteriorly, by means of a large branch with the first aortic intercostal and posteriorly with the posterior branch of the same artery. (3) The inferior thyroid, by means of a branch about the size of an ordinary radial, formed a communication with the first aortic intercostal. (4) The transversalis colli, by means of large communications with the posterior branches of the intercostals. (5) The branches of the subclavian and axillary going to the side of the chest were large, and anastomosed freely with the lateral branches of the intercostals.

CHAPTER V.

LIGATURE OF THE INNOMINATE.

Instruments required in Ligature of Arteries.—Scalpel or straight bistoury, director, dissecting forceps, blunt hooks, a pair of broad, bent copper spatulæ, aneurism needles of various shapes, waxed silk or chromic acid catgut ligatures, a pair or two of Péan's forceps, means to command the hæmorrhage, sponges, etc. In operating on the **dead body** the instruments required are—(1) A scalpel; (2) a dissecting forceps; (3) a director; (4) retractors or blunt hooks; (5) an aneurism needle; (6) a pair of Well's or Péan's forceps, or the ordinary toothed artery forceps; (7) a ligature; (8) scissors. These must *all* be selected before beginning the operation, and placed in a small tray within easy reach of the operator's right hand. **Assistants** required:—No. 1, to administer chloroform. No. 2, to hold and steady the limb, etc. No. 3, with a blunt hook in each hand, holds apart the edges of the wound as layer after layer of the tissues are divided; and further, tries to lessen the depth of the wound as much as possible, putting the part into such a position as to relax muscles, etc. No. 4, standing in front of the operator, and with small sponges on the ends of sticks, keeps the wound free of blood, and assists the operator to tie the bleeding vessels. No. 5, standing behind the operator, hands him the instruments he requires. No. 6, to wash sponges and hand them to assistant No. 4.

CHLOROFORM.

As this is the first time I have had occasion to speak about chloroform, a few words as to its administration will not be out of place. In Edinburgh, chloroform is the agent usually employed to produce anæsthesia: it is more convenient than ether in many

ways—the bulk required is less, it is more agreeable to the patient, is more easily administered as it requires no special apparatus, and the patient is more easily put under. With ether a special apparatus is required, as it must be administered nearly pure, the stage of stimulation is more protracted, its smell is less pleasant to the patient, and it irritates the respiratory tract much more than chloroform; but it causes less cardiac depression, so that it should be always at hand to be used in cases where the pulse shows signs of failure, or where the heart is weak and fatty; but it is only to be used as an adjunct to chloroform, and in special cases, when the patient may be put under by chloroform and kept under by ether, *e.g.*, in mitral disease. It (ether) must be avoided in cases of chronic bronchitis, emphysema, and other pulmonary affections, as it causes so much irritation of the bronchial mucous membrane, and its subsequent risks are much greater than chloroform; it should not be given to children, nor used in cases where the operation is conducted by the aid of artificial light, as the vapour of ether is inflammable. It should not be used in operations about the mouth, as it causes a profuse secretion of ropy mucus: it is said to be safer than chloroform, but this is still an open question.

A towel folded in the form of a Λ is all that is required for the administration of chloroform; folded thus, and tightly applied to the chin and side of face, it allows the administrator to see the patient's face, and watch the respirations, as well as to observe changes in colour, and further, allows a free admixture of atmospheric air. It is not so wasteful as at first sight it seems to be, because the vapour of chloroform is heavier than atmospheric air, and hence falls down towards the patient's nostrils. It is found that 3 to 4 per cent. of chloroform, along with 97 or 96 per cent. of air, is the proper proportion to use. The objection to SKINNER's inhaler is that one cannot easily feel whether the patient is breathing or not: this could be obviated to a certain extent by leaving an opening in the flannel and inserting a valve of some delicate and easily movable material. The objection to ALLIS's inhaler is the gutta-percha forming its investing framework: I believe that the volatile gases given off by this material (especially when new), and inhaled by the patient, are a frequent cause of persistent vomiting after

the operation. At any rate, frequent vomiting is of very common occurrence in those who are "new hands" at rubber factories. This objection could be got rid of by substituting a thin sheet of block tin for the gutta-percha.

The **Risks of Chloroform**, unlike ether, are immediate and not remote, and principally concern the Heart, the Lungs, and the Stomach. The last is only dangerous as it affects the air passages, I mean from sickness and vomiting. One is often told that it is most important to examine the heart carefully before giving chloroform. This is best answered in the words of Sir JOSEPH LISTER—"Preliminary examination of the chest, often considered indispensable, is quite unnecessary, and more likely to induce the dreaded syncope, by alarming the patient, than to avert it." Not only is it unnecessary but it may even do harm, as it directs the student's attention in the wrong direction.

The **Action of Chloroform** is—(1) Stimulant; (2) depressant; and (3) if its administration be continued beyond this point, it will cause death by the complete loss of all reflex excitability of the cord and medulla, the last centres to be extinguished being those of organic life—the respiratory, cardiac, and vascular centres. The order in which the various parts of the nervous system are affected is very interesting. It first affects the convolutions of the cerebrum, beginning in front and passing backwards: thus the highest centres (psychological) are first affected, then comes the motor centres and those of special and common sensation. The lower cerebral and spinal centres are affected less and later; lastly, the lowest centres of all are affected, viz., those of organic life—first, the respiratory centre, and then those connected with the heart. These last are not affected to any great extent until *after* the functions of the higher parts (and, therefore, all voluntary muscular efforts and ordinary sensation) are completely overpowered; it is this safe order of invasion that gives to chloroform its great value as an anæsthetic. During the first stage, the pupils may dilate slightly: during the second stage, the pupil is contracted, dilating on stimulation of afferent nerves: during the third stage (the stage of danger), the pupils are widely dilated and fixed.

No solid food should be given for at least four hours before the operation—(1) because the patient is more easily anæsthetised when

the stomach is empty; and (2) because we avoid in this way the special risk of vomiting under anæsthesia—viz., solid matters passing into the glottis and choking the patient. It is a good plan, however, to give half-an-ounce of brandy mixed with an ounce and a half of water about half-an-hour before the operation. The chloroformist should not deluge his patient suddenly and without warning with the chloroform vapour, but should first converse with him for a few minutes to gain his confidence, reassure him as to the result, and instruct him how to breathe. This, of course, does not apply to young children.

No *single* sign can be relied upon as a sure test of insensibility; the tests usually employed are—(1) Loss of the corneal reflex; (2) relaxation of voluntary muscular action; (3) local insensibility of the part to be operated upon: the Surgeon tries this by gently pricking the part with the point of his knife. The corneal reflex may be lost and yet the part to be operated upon be widely awake, especially if in the neighbourhood of the anus and rectum, the penis and perineum; or, again, the part to be operated upon may be completely insensible while the corneal reflex is still active.

The **Risks from the Heart** are fortunately rare, because as a rule, in man, the respiration stops before the heart has ceased to beat. It may, however, fail in one of two ways—either by sudden syncope, or gradual dying out. The sudden failure is probably due in most cases to the fact that the patient is not sufficiently under to abolish all reflex action when the operation is begun; hence, the sudden shock, produced by division of the cutaneous structures, reaches the medulla and there stimulates the cardio-inhibitory centre, and at once brings the heart to a stand-still in diastole. If this be the correct explanation, then the proper way to prevent it is to see that the patient is deeply under when the operation is commenced. For the same purpose, it has also been recommended that a mixture of atropia and morphia (one-sixtieth of a grain of atropia, and one-sixth of a grain of morphia) should be given subcutaneously a short time before the operation, as the patient then not only requires less chloroform (from the narcotic effect of the morphia), but the atropia paralyses the whole inhibitory mechanism, and thus prevents, it is asserted, the passage of inhibitory impulses from the medulla to the heart. I am not at all

sure about this, but in any case it certainly can do no harm and may possibly do some good; it is stated, however, that it predisposes to after sickness. It will certainly do harm, if the chloroformist thinks that, because it is used, he need not therefore be quite so very careful in giving the chloroform; whatever is given, he must never relax his vigilance for one moment, but must regard every case as dangerous, and use all possible precautions to prevent accidents. Usually the respirations cease before the heart; but sometimes the heart ceases before the respirations, as it does, normally, in the dog.

The operation of tooth-pulling seems to be a specially frequent cause of sudden death under chloroform. This may arise from various causes—(1) The patient not being deeply enough under when the operation is commenced, and the pain produced causing sudden reflex inhibition of the heart. There can be no doubt that the large sensory root of the fifth nerve has intimate and extensive relations with the medulla oblongata and with the cardiac and respiratory centres there situated. If this be so, care should be taken that the patient is *deeply* under before the forceps is introduced. The temptation is merely to give them a whiff just to deaden sensation a little, but nothing could be more dangerous than this: it must be *deeply*, or not at all. It would probably also be advantageous to give the patient ten to fifteen grains of butyl-chloral hydrate a little while before beginning the operation, as this substance specially paralyses the sensory part of the fifth nerve, producing anæsthesia of the parts supplied by it, before general anæsthesia is produced. (2) The tongue may fall back. This is specially apt to happen when pulling the posterior molars, as the forceps itself may *push* it back. For this emergency, have the toothed artery forceps *ready*, and pull the tongue forward at once. (3) The tooth or the gag may loosen and fall back, causing sudden spasm of the glottis. In all cases, see that the patient maintains the *recumbent posture*, as, otherwise, syncope may occur and induce cardiac failure.

The **Risks from Respiration.**—It may be arrested while the heart is still beating, and this may take place either suddenly or more slowly. The *slow* stoppage is probably due to the toxic effects of the chloroform on the respiratory centre, while the sudden

is usually from falling back of the tongue, or paralysis and adhesion of the vocal cords in such a way as to make *inspiration* impossible, but yet allow of *expiration*—from the slightly oblique position of the cords in the vertical direction. In this condition, the movements of the chest are apt to mislead the unwary, as it is heaving vigorously, and yet no air is entering the windpipe. For the respiratory dangers of this class, the best treatment is to see that the tongue is pulled well forwards, and the vocal cords separated, and then use artificial respiration (SYLVESTER'S Method). If this is not sufficient, then perform laryngotomy, and forcibly blow air into the lungs, as they have stopped in full expiration, and after this use artificial respiration.

But the respiratory process may be affected in another way—asphyxia from vomited matters or blood. To avoid this, see that the patient has had no food for some hours before the operation, so that the stomach is empty, and operate in such a way or with such precautions that no blood can pass through the chink of the glottis. There is reason to believe, as LISTER, I think, points out, that sickness is often induced by administering the chloroform by fits and starts—allowing the patient almost to recover consciousness, and then to suddenly give him a great gust of the vapour. At any rate, sickness is most common when the patient is *half under*, whether it be just as he is going under at first, or that he is allowed to partially regain consciousness during the progress of the operation.

Children are peculiarly favourable subjects for chloroform, and it is best to suffocate them at once, unless they can be coaxed into taking it. There is absolutely no danger in so doing. This has been explained on physiological principles, but I am inclined to think that it does not depend so much on physiological as upon psychological causes. The child truly takes no thought for its life, but the adult is careful and troubled about many things: in this respect, the child has chosen the better part.

In the **Adult**, give gently and slowly at first with a free supply of atmospheric air; and should there be much struggling, remove the chloroform altogether, and allow him to take a good breath or two, and probably before he feels in need of another such breath he will have passed quietly under. Let me also give a single hint

to those who are ever ready to pin the struggling patient to the operating table—do not grasp the patient's wrists and legs as if you had a mad bull by the horns; do not fight with him, but let him grasp *your* hand, and all that will then be required will be simply to direct his movements and not to forcibly restrain them. A person under chloroform is like a drunk man—the more you try to resist him, the more he fights. In all cases, there should, as far as possible, be perfect quiet round about the patient until he is under.

Alcoholics are specially bad subjects for chloroform, and require special watching and care. At first the struggling is great, and then, almost before one is aware of it, they pass suddenly and deeply under, and are in great danger of paralysis of the heart or respiration from over-dose; and yet, if the chloroform is withdrawn, they rapidly regain consciousness.

In all cases, watch the *breathing* above everything else, and see that air is *entering* the chest. There are two danger signals, as a rule, before the case becomes very serious—(1) *Snoring respirations* —this is due to vibration, and probably paralysis of the velum palati; and is the signal, in most cases, to remove the chloroform for a time. (2) *Laryngeal stertor* or *stridor*, from paralysis of the vocal cords, and which then flap together like a reversed V, and make the *entrance* of air almost impossible. This is the signal of real danger, and requires active treatment—stop the chloroform, pull forward the tongue, and, if necessary, put a finger down and separate the cords, and then artificial respiration. The chloroformist must be prepared to give *all* his attention to his own duty. One of the most annoying sights I know is to see the chloroformist staring inanely at what the operator is doing, or else gazing up at the crowded benches of the operating theatre, just as if he meant to say to the other students, "Am not I a great man?" or "Wouldn't you like to be me?"—perhaps at the very moment when the life of the patient committed to his care is wavering in the balance. The patient's mouth should, if possible, be turned away from the part being operated upon.

I will now give a short *résumé* of the points that must be always kept in mind by the chloroformist under three heads, after the manner of railway signals:—

D

I.—WHITE (= right).

1. When the chloroformist gives ALL his attention to his duty. Before beginning he ought to see that the patient has nothing movable in his mouth, as false teeth, sweets, etc.

2. When he has a toothed artery forceps handy—usually attached to the left lapel of his coat.

3. When muscular relaxation is complete, and the reflexes of the conjunctiva *and the part to be operated upon* are abolished: this is determined by gently pricking the part.

4. When the heart is beating regularly.

5. When air *enters* the chest easily.

6. When there is neither snoring nor stertor.

7. When there is an absence of extreme pallor or marked blueness of the face.

8. Have ether, and brandy, and capsules of nitrite of amyl, always at hand; and a hypodermic syringe full of ether and ready to inject subcutaneously at a moment's notice.

Above everything, watch the patient's breathing. For this purpose, the tips of the fingers of one hand may be laid on the symphysis menti, with the palm a little distance above the mouth and nostrils, so that you may be able to *feel* whether the patient *breathes or not*, as the mere heaving of the chest is not a trustworthy guide. Use especial care and precaution in the case of alcoholics. See that the patient is deeply under, during incisions through the skin and in cutting large nerves.

II.—GREEN (= proceed cautiously).

1. When snoring (= vibration of the velum palati) accompanies the respirations. Remove the chloroform for a little, and be ready to pull forward the tongue by the toothed forceps. In these cases it is often advised that the chin be tilted upward, but this is of no use at all as it does not pull forward the tongue—the lower jaw is simply jammed against the upper. The proper plan is to place the thumbs half-an-inch or so above the angles of the lower jaw and *push;* in this way the chin is pushed forward, and with it the genio-hyoid, and it in turn pulls forward the base of the tongue. Dr HOWARD denies that traction of the tongue can raise the epiglottis, but states that "the new and only way" to ensure a

clear air-way to the lungs is by sufficient extension (or rather over-extension) of the head and neck, over the end, say, of the operating table, at the same time tilting up the chin as far as possible.

2. When vomiting is threatened. This may very often be warded off by giving more chloroform.

3. When there are signs of cardiac failure. If so, stop the chloroform and use ether instead, and also inject ether subcutaneously.

III.—**RED** (= **danger: stop**).

1. When there is sterterous or stridulous breathing:—This is laryngeal in its cause and is probably due to paralysis of the vocal cords; this allows them to flap together, as I have already explained, and effectually prevents the *ingress* of air. For this, stop the chloroform, pull the tongue well forwards, and if necessary pass finger down to and separate vocal cords, and raise the epiglottis, and then use artificial respiration; or laryngotomy and forcible inflation may be used as the lungs stop in expiration. Ether may also be injected subcutaneously.

2. When he vomits turn him at once on his side, and let the head hang low so that the vomited matters may pass out easily, and not pass into or through the chink of the glottis.

3. At whatever stage, when there is *much struggling*, the danger is very great. Such patients are often alcoholic, and during the struggle, especially when held forcibly down, the muscles being all contracted, prevent the outflow of blood from the aorta and thus over-fill the left ventricle leading to its paralysis; further, the blood is insufficiently ærated, and at the same time the deep inspiratory gasps the patient takes, quickly leads to over-filling of the lungs with the vapour, and rapid poisoning of the patient follows. In such cases remove the cloth for a little, and let him get the lungs well filled with air, guide but do not forcibly control his struggles, but keep his head down. Under Red, therefore, note these three points:—Laryngeal stridor, vomiting, and struggling.

Allow the patient to sleep quietly in bed till the effect of the narcotic passes off; do not adopt the disgusting practice of slapping the patient's brow with the palm of the hand or tapping with the finger nails in order to bring him to; all you have got to do is to remain beside him till he returns to consciousness.

In concluding this section let me enumerate the chief **risks or** modes of death:—

THE HEART.

1. Failure may be induced by the **fainting** or **syncope** induced by or accompanying vomiting; this is most likely to occur when the patient is but half under, or should he suddenly assume the upright position; it may also be caused by fatty heart occasionally, or be the result of a prolonged operation. The face is very pale, and in such cases the head should be lowered or even allowed to hang over the end of the table; the vapour of nitrite of amyl may be inhaled and ether injected subcutaneously.

2. The heart may fail suddenly from **reflex inhibition.** To avoid this see that the patient is deeply under, or atropia may be injected previously.

3. It may gradually fail from **overdose** of chloroform, the medullary centres and the intrinsic ganglia being gradually poisoned.

4. Sudden failure before the respirations have ceased, without evident câuse ("**primary failure**"). This form is fortunately rare, but when it does occur little can be done. Treat the case as one of asystole—inject ether, brandy, or digitalis; inhale amyl nitrite, and keep up artificial respiration.

THE RESPIRATION.

1. It may be interrupted by **falling back of the tongue.**

2. It may be stopped by the **glottis closing**; this is usually preceded by snoring, stertor, or stridor.

3. It may stop slowly from **overdose** of chloroform, the respirations gradually dying away, the centres being slowly poisoned.

4. The glottis may be blocked up or thrown into spasm by the entrance of **vomited matters.**

Note.—(1) That the chest may be heaving vigorously and yet no air enter, as the tongue may have fallen back, or the glottis closed. (2) That air may be expired and yet none be inspired, as the glottis may flap together in such a way as to prevent inspiration, but yet allow of a certain amount of expiration.

We may also look at this question from another point of view: the continuance of life depends on the proper and regulated action of the heart, the lungs, and the brain. These three organs therefore form the tripod of life, and arrest of the functions of any one of them very speedily leads to the arrest of the others, so that either of the three may be the primary cause of death. Thus death may (1) **begin at the heart** in those rare cases of sudden and primary failure without recognisable cause, in cases of syncope, and in paralysis from over-filling. (2) Death may **begin at the lungs** from some impediment to the entrance of air, as falling back of the tongue, closing of the glottis from paralysis, or spasm of the glottis from the entrance of vomited matters or blood. (3) Death may **begin at the brain** from over-dose, gradually poisoning the respiratory and cardiac centres, or from a sudden stimulation of the inhibitory centre bringing the heart to a stand-still in diastole; a similar condition may also be caused by strong mental emotions. In syncope, the brain is only affected secondarily, because, as the heart has stopped or is very weak, it is deprived of its proper supply of blood.

INNOMINATE ARTERY.

This artery has also been named **Brachio-Cephalic**, from its being distributed to the arm and head. Aneurism of this vessel is extremely difficult to diagnose with certainty, as indeed are all aneurisms at the root of the neck. Many cases diagnosed as aneurism of the innominate during life, have been discovered after death, by the more perfect light of the post-mortem room, to be aneurism of the arch of the aorta. Aneurism of the innominate forms a pulsating swelling behind the sternum, or perhaps more frequently situated on the tracheal side of the right sterno-mastoid muscle, filling up the episternal notch, and giving rise to certain **special symptoms,** chiefly from pressure of the tumour on neighbouring structures. (1) The pulse on the affected side is small, feeble, and delayed, and so is the pulsation in the right carotid. (2) The superficial veins of the right side of the neck and face, and of the right arm, are enlarged, and hence the œdema of the right eyelid and arm. (3) There are dull aching pains (or they may be sharp and shooting) from pressure on, and irritation of, the cervical

and brachial nervous plexuses. (4) Dyspnœa from pressure on the right recurrent laryngeal nerve, or by direct compression of the trachea. (5) Difficulty in swallowing, which usually occurs after the dyspnœa, as the nerve is first affected. (6) If the cervical sympathetic be *irritated* there will be dilatation of the pupil of the affected side; but, if it be completely *paralysed*, the pupil on that side will be contracted and there may be sweating and redness of that side of the face and neck. The same remark applies to aneurism of the common carotid.

Origin.—From the right side of the transverse part of the arch of the aorta at a point corresponding to the middle of the manubrium sterni. **Extent.**—From the above point upwards and to the right, to the posterior aspect of the right sterno-clavicular articulation and lower cervical region, where it bifurcates into the right subclavian and right common carotid. Its entire length is from 1½ to 2 inches. **Course.**—Upwards and to the right, behind the first piece of the sternum. Its most important **Relations** are:—In *front*—(1) The first piece of the sternum. (2) Lower part of the sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles. (3) It is crossed by the left innominate vein, and there is also a network of thyroid veins in front of it, embedded in the loose cellular tissue. On its *right* side—(1) The right innominate vein; (2) vagus; (3) phrenic; (4) inferior cardiac of right vagus; (5) pleura. On its *left* side, the left common carotid. *Behind*—(1) Trachea, at lower part: (2) pleura and apex of the right lung.

THE OPERATION.

In ligature of this vessel the **patient** should be in an easy recumbent posture, with the shoulders raised, the head thrown back and turned towards the left shoulder; the right arm should be well drawn down and adducted. The **Surgeon** should either stand in front of, or facing, the right shoulder.

Superficial Guide to the Vessel.—It lies just behind the right sterno-clavicular articulation. **Incision.**—The incision should be V-shaped. First make an incision about two inches long over the inner part of the clavicle and sterno-clavicular articulation to the

sternum; another, two or three inches in length, along the inner border of the right sterno-mastoid muscle, meeting the other at the sternum at an acute angle. By these incisions we divide—(1) Skin; (2) platysma and fascia; (3) sternal head and inner part of the clavicular head of the sterno-mastoid, which may be divided on a director. These are thrown upwards and outwards, and then we cut through—(4) sterno-hyoid; and (5) the sterno-thyroid. Before dividing the sterno-hyoid, look out for the anterior jugular vein, which lies on this muscle, covered by the sterno-mastoid. The head is now drawn well back in order to draw up the artery into the neck as much as possible, the left innominate vein, which crosses the artery, being fixed by its relations to the right innominate vein and the superior vena cava, does not rise with the artery.

Deep Guide to the Vessel.—Trace down the common carotid with the finger till the bifurcation of the innominate artery can be *distinctly felt;* then (6) draw the inferior thyroid veins carefully to one side, clear the vessel with the finger and director from the surrounding cellular tissue, and ligature, taking care not to wound the pleura; the needle is passed *from the outer side* in order to avoid the right innominate vein and right pneumo-gastric nerve, and in passing it be careful to keep its point close to the artery, in order to avoid wounding the pleura covering the apex of the right lung. The veins are the great trouble in this operation, as they become turgid, and obscure the various steps of the operation: there is also the risk of entrance of air should they happen to be wounded.

RÉSUMÉ of the chief steps in this operation:—

1. Make the V-shaped incision and divide the integumentary structures.
2. Divide the whole, or part, of the sterno-mastoid on a director.
3. Secure anterior jugular vein.
4. Divide both sterno-hyoid and sterno-thyroid.
5. Draw the head well back, follow down common carotid, and turn inferior thyroid veins, fat and glands, to one side.
6. Clear the vessel and pass the needle from the outer side.

The **Collateral Circulation** is practically the same as in ligature of the common carotid, added to that of ligature of the right subclavian (see Fig. 12).

PECULIARITIES.—As a rule, the innominate gives off no branch; but occasionally a small branch, the *thyroidea ima*, arises from it and runs up in front of the trachea to the thyroid body: further, it is by no means an uncommon arrangement to find the left common carotid joined with the innominate artery at its origin. In some cases there is no innominate artery, the right subclavian arising directly from the arch of the aorta; hence, the importance and necessity of the "deep guide," viz., to trace down the common carotid with the finger till the bifurcation of the innominate artery is *distinctly felt*. Occasionally, its point of division is considerably above the sterno-clavicular articulation; less frequently, it divides below that point. When the aorta, as in birds, is a "right aorta," the innominate artery is on the left side of the neck instead of the right side. It will also be on the left side in cases of the rare congenital malformation of "*transposition*" of the thoracic viscera, when everything, as it were, lies on the wrong side.

Ligature of the innominate is not a successful operation, and can hardly be regarded as justifiable, and is now practically abandoned. In a large proportion of cases (one-fifth of all) the operation has had to be abandoned, on account of unforeseen difficulties, discovered only during its progress. To render the passing of the ligature more easy and certain, the inner end of the clavicle and the upper part of the sternum has been removed by COOPER of San Francisco. It has also been proposed to ligature the vessel through a trephine hole in the manubrium sterni, just over the vessel.

It is scarcely necessary to remind the reader that there is but *one* innominate artery (though there are two innominate veins), and that it is on the right side. It does not look well when a student rises from the examination table and asks the examiner on *which* side he wishes the artery tied. It is apt to raise a *suspicion* in that gentleman's mind, which is likely to be noted for future verification, that the student must have forgotten his anatomy considerably. It is specially awkward to make *such* a mistake at *such* a time; for, if ever a student's words ought to be few and well chosen, it is at an examination.

TREATMENT OF INNOMINATE ANEURISM.

For the treatment of innominate aneurism various methods are adopted. All operative measures have, as yet, been very unsuccessful, the patients usually dying in a short time after the operation from secondary hæmorrhage, inflammation and gangrene of the lung, or inflammation of the pleura; and, in all probability, death has in most cases only been hastened by the operation. We have—(1) *Medicinal and dietetic* treatment—the most trustworthy and safest method. (2) *Ligature of the innominate* artery itself—usually of little use, and only hastens death. It can only, by any possibility, be successful if the artery is healthy and the aneurism limited. In tubular aneurism, where the coats are diseased, it is worse than useless, as the diseased artery gives way in a few hours under the pressure of the ligature, with fatal hæmorrhage. (3) Ligature on the *distal side of the aneurism* (WARDROP). We may tie—(*a*) the subclavian alone; (*b*) the carotid alone; (*c*) both arteries, either simultaneously, or tie the carotid first and then the subclavian, after a longer or shorter interval—should the patient be fortunate enough to survive the first operation. It is probably better to tie both branches at once, as this gives the best results, and is not a more serious operation. Mr HEATH has had one successful case, where he tied the common carotid and the third part of the subclavian simultaneously in 1865—the woman lived for four years. Excluding Mr HEATH's case, and one or two other more recent cases of a similar nature, neither of these methods have been followed by any marked success, on account of the disturbance on the cardiac side of the ligature, which renders the probability of consolidation taking place in the sac all but hopeless; and, besides, the ligature is applied so close to the aneurism that the coats at the point of application are almost certainly diseased—the danger, therefore, of secondary hæmorrhage is very great. (4) *Introduction of foreign bodies* into the sac, such as fine iron wire, horse-hair, or catgut, through a fine canula or hollow needle, after the manner of LORETA. Mr ANNANDALE has suggested that the artery be compressed through a central incision, as in low tracheotomy, by inserting the finger behind the artery, and compressing it against the sternum.

CHAPTER VI.

SUBCLAVIAN ARTERY.

Origin.—On the *right* side from the branching of the innominate artery behind the sterno-clavicular articulation. On the *left* side directly from the arch of the aorta. **Extent** (in neck).—From the sterno-clavicular articulation, or opposite the interval between the two heads of the sterno-mastoid, to the lower border of the first rib. It is divided into three parts by the scalenus anticus muscle—a part internal to (first part); a part behind (second part); and a part external to that muscle (third part). **Course.**—It crosses the lower part of the neck, taking an arched course over the apex of the pleura and first rib, passing between the anterior and middle scaleni muscles, and ends opposite the middle of the clavicle. It usually rises about one inch above the clavicle. The right subclavian is about three inches long, the left is one inch longer.

RIGHT SUBCLAVIAN.—First Part.

This part extends from the right sterno-clavicular articulation to the inner edge of the scalenus anticus muscle. An aneurism of the first part of the subclavian usually presents as a pulsating tumour external to the sterno-mastoid muscle, more or less elongated transversely, with bruit propagated *into the axilla*, which is unaltered when the common carotid is compressed. The right side is more frequently affected in the proportion of three to one, probably because the right arm is more used than the left. **Relations.**—*In front*—(1) Skin and superficial fascia; (2) platysma; (3) deep fascia; (4) three muscles—sterno-mastoid, sterno-hyoid, and sterno-thyroid; (5) three veins—internal jugular, vertebral, and anterior jugular; (6) three nerves—vagus, branches of sympathetic (cardiac, and ansæ Vieusenii), and phrenic (the phrenic is always in front

on the left side, and very often on the right side too, but usually close to the inner edge of the scalenus). *Behind*—(1) Longus colli muscle separated from it by loose connective tissue, in which we find three nerves—the gangliated cord of the sympathetic, the recurrent laryngeal, and the cervical cardiac branch of the vagus. *Below* is the pleura and the recurrent laryngeal nerve. *Above*, there is nothing worth noting.

There are several grave objections to the ligature of this part of the subclavian—(1) Its great depth. (2) Its complicated relations; for these two reasons its ligature is one of the most difficult and serious operations in surgery. (3) Its shortness and the number of branches it gives off; it is only about one inch and a half in length, and gives off three large branches, so that its ligature is almost certain to be followed by fatal secondary hæmorrhage when the ligature separates. (4) When tied for spontaneous aneurism there is always the serious risk of the coats of the artery being diseased, so that they are unable to bear the ligature. (5) The disturbance both on the cardiac and distal side of the ligature render the formation of a sufficient coagulum all but hopeless. On the cardiac side there is the onward rush of blood in the innominate artery, and on the distal side there is the regurgitant stream through the vertebral, thyroid axis, internal mammary and superior intercostal. In almost every recorded case in which this operation has been performed, the patient has been carried off by fatal secondary hæmorrhage from the distal side, on the separation of the ligature, on account of the presence of these large branches.

THE OPERATION.

In ligaturing the first part, the patient should be in an easy recumbent posture, with the shoulder depressed, the head thrown back, and the face turned to the opposite side; the Surgeon should stand in front of the shoulder on which he is about to operate, and the corresponding arm should be well pulled down and placed close to the patient's side. An incision should be made transversely over the origin (sternal and clavicular) of the sterno-cleido-mastoid, and another, two or three inches in length, along the inner border of the same muscle, meeting the first incision at an acute angle. The V-shaped flap thus marked out, consisting of integument with

the platysma and deep fascia, is then turned upwards and outwards. The sternal head of the sterno-mastoid, and part or whole of the clavicular head, is next divided on a director and turned outwards. Avoid the anterior jugular vein and its communications, and divide the sterno-hyoid and sterno-thyroid muscles in the same manner. Carefully separate the cellular tissue with the handle of the scalpel or the finger-nail, when the artery, with the internal jugular vein, will be brought into view. At the lower part of the wound the internal jugular vein inclines away from the artery, leaving the pneumo-gastric nerve visible. The proper point for the application of the ligature is in the space between the vagus and the recurrent laryngeal nerve on the inner side, and the thyroid axis, phrenic nerve, internal jugular vein, and cardiac nerves on the outer side. The **deep guide** for the ligature of this vessel is to trace down the carotid to the bifurcation of the innominate, and then the subclavian artery is to be followed outwards till the vagus nerve is recognised by the finger. The internal jugular vein is pressed out of the way, and the nerves drawn aside in the direction indicated, the vessel cleared with the finger and director, and the needle passed from below upwards, but in doing so be careful not to injure the pleura or the right innominate vein, or include the vagus nerve. The subclavian vein is in front of the artery, and on a much lower level, being under cover of the clavicle and subclavius muscle, so that it is not likely to give any trouble during the operation. Occasionally, however, it rises in the neck as high as the artery, and in two cases it has been found accompanying the artery behind the scalenus anticus muscle.

LEFT SUBCLAVIAN.—First Part.

This vessel arises from the end of the transverse part of the arch of the aorta, opposite the middle of the first piece of the sternum, and extends to the inner edge of the scalenus anticus. It differs from the right in being—(1) Much longer; (2) more deeply placed; (3) it ascends almost vertically upwards from its point of origin to its termination. **Relations.**—In *front*—(1) Left pleura and lung; (2) left internal jugular and innominate veins; (3) the same three muscles as on right side—sterno-mastoid, sterno-thyroid, and sterno-hyoid; (4) the same three nerves as on the

right side—pneumo-gastric, cardiac, and phrenic. It lies on a plane posterior to the left common carotid. *Behind*—It lies on —(1) The œsophagus; (2) thoracic duct; (3) sympathetic and cervical cardiac branches of vagus; (4) longus colli muscle. To the *inner side*—(1) The œsophagus; (2) trachea; (3) thoracic duct. To the *outer side*, pleura and lung. It is generally taught that the relations of this part are too complicated to admit of ligature. Should it be found necessary to do so, the **incision** and the steps of the operation resemble the ligature of the corresponding part on the right side, but great care is necessary to avoid injury to the pleura and thoracic duct.

Collateral Circulation (Fig. 12).—When the **first part** is tied the following vessels re-establish the circulation:—1. The superior intercostal (18) anastomosing with the aortic intercostals (30) and internal mammary (31). 2. The inferior thyroid anastomosing with the superior thyroid (10). 3. By the inosculations of the vertebrals through the circle of Willis (1). 4. Internal mammary (29) anastomosing with the deep epigastric (28) and aortic intercostals (30). 5. The thoracic branches of the axillary (21, 26) anastomosing with the aortic intercostals (30). 6. The princeps cervicis (6) of occipital anastomosing with the profunda cervicis (11) from subclavian. 7. Branches from the thyroid axis going to the scapula (14, 15), anastomosing with the thoracics of the axillary (17, 21, 26), and through them with the aortic intercostals (30).

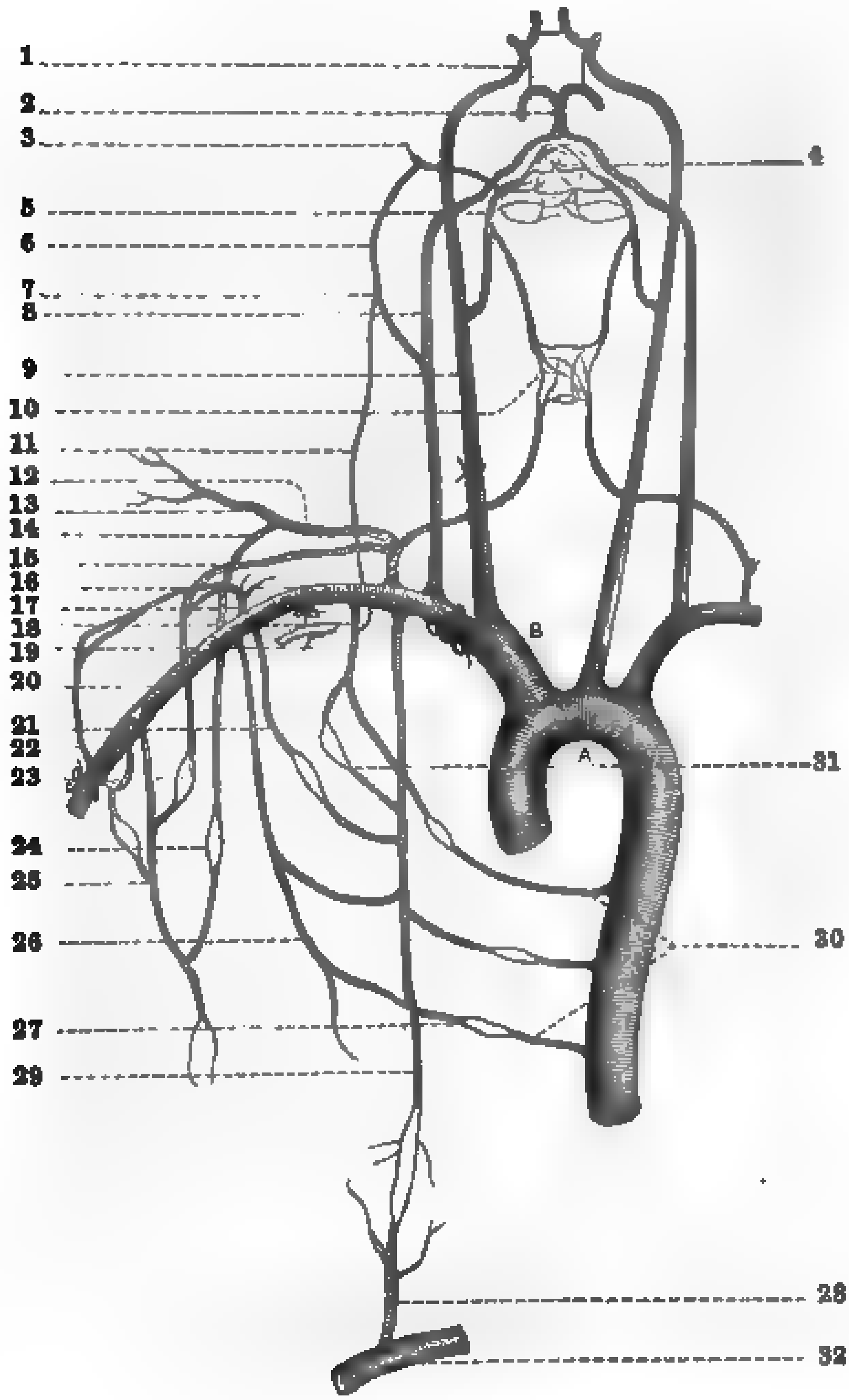
SECOND PART OF SUBCLAVIAN.—Right and Left.

This part of the artery lies beneath the scalenus anticus muscle, and is the shortest and highest of the three divisions. It *may* be tied in this situation, but it is necessarily a dangerous and difficult operation.—(1) On account of the depth of the vessel. (2) Its close relations to the phrenic nerve, transversalis colli and suprascapular arteries; and (3) because it rests on the pleura and first dorsal nerve. On the **right** side it gives off one branch, the superior intercostal, and this is likely to interfere with the formation of a proper clot; on the **left** side it usually gives off no branch, the superior intercostal arising from the first part, on the left side. **Relations.**—In *front*—(1) Skin, fascia, and platysma; (2) sternomastoid; (3) branches of thyroid axis (transversalis colli and supra-

Fig. 12.

COLLATERAL CIRCULATION OF THE HEAD AND NECK.

(After SMITH and WALSHAM.)



Explanation of Fig. 12.

A. Aorta. B. Innominate Artery.

1. Circle of Willis, formed by the posterior cerebrals from the basilar, and the anterior cerebrals from the internal carotids, connected together by the anterior and posterior communicating branches.

2. Basilar artery, formed by the union of the two vertebrals.

3. Occipital artery, from the external carotid.

4. To represent the anastomoses between the corresponding branches of the two external carotids—viz., facial with facial, lingual with lingual, temporals with temporals, and occipital with occipital.

5. External carotid. 6. Princeps cervicis, from occipital.

7. Anastomoses between the princeps cervicis, vertebral and profunda cervicis in the region of the sub-occipital triangle.

8. Vertebral, from the subclavian. 9. Common carotid.

10. Anastomoses between the two superior and the two inferior thyroids in the region of the thyroid gland.

11. Profunda cervicis, from the superior intercostal.

12. Transversalis colli. 13. Its superficial cervical branch.

14. Posterior scapular artery, one of the divisions of the transversalis colli branch of thyroid axis; the other division is called the superficial cervical, and enters the trapezius.

15. Supra-scapular artery from the thyroid axis, anastomosing with the subscapular from the axillary. 16. Subclavian artery.

17. Thoracic axis, from the axiliary anastomosing with the supra-scapular and posterior circumflex.

18. Superior intercostal, anastomosing with the internal mammary and the aortic intercostals.

19. The first rib. 20. Axillary artery.

21. Superior or short thoracic, anastomosing with the internal mammary.

22. Posterior circumflex, anastomosing with the thoracic axis and the subscapular.

23. Anastomosis between the supra-scapular and the subscapular.

24. Anastomoses between the posterior scapular and the subscapular. 25. Subscapular artery.

26 and 27. Long thoracic, anastomosing with the internal mammary and the aortic intercostals.

28. Deep epigastric from the external iliac.

29. Internal mammary. 30. Aortic intercostals.

31. Anastomoses between the internal mammary and the superior intercostal. 32. External iliac.

scapular); (4) phrenic nerve; (5) scalenus anticus muscle; (6) the subclavian vein is separated from the artery by the scalenus anticus, and is on a much lower level as a rule. *Behind*—(1) Pleura; (2) middle scalenus; (3) first dorsal nerve. *Above*, we have the brachial plexus, while *below* it rests on the pleura. Should it be necessary to tie this part, the vessel may be reached by means of the following incisions—a transverse one over the clavicular head of the sterno-mastoid, from two to three inches in length, and a vertical one about two inches long, rather external to the outer border of the sterno-mastoid, meeting the former at an acute angle; the position of the Surgeon and patient are the same as for ligature of the first part. The flap thus mapped out, consisting of the integument platysma and deep fascia, is raised upwards and inwards, and the external jugular vein drawn outwards, if necessary; the clavicular head of the sterno-mastoid is then divided from without inwards, on a director, in order to expose the scalenus anticus. Lying on this muscle the following structures will very likely be seen—(*a*) the internal jugular vein along its inner border; (*b*) the transversalis colli and supra-scapular arteries, and the anterior jugular vein; (*c*) the phrenic nerve; (*d*) in some cases also the external jugular vein along its outer border. These structures must be drawn aside in the most convenient manner and carefully guarded from injury. A director is next pushed under the outer edge of the scalenus anticus, which is then to be cautiously divided for a half or two-thirds of its extent when it retracts sufficiently to bring the artery into view, and after carefully clearing the vessel the aneurism needle is passed from below upwards. As a guide to the position of the scalenus anticus it is useful to remember that the outer edge of the sterno-mastoid almost corresponds to the outer edge of that muscle, though the scalenus is slightly external, and the external jugular vein often rests on the uncovered part.

NOTE.—(1) In dividing the scalenus anticus special care must be taken to avoid cutting or bruising the phrenic nerve, which lies on its anterior surface, inclining obliquely towards its inner border. Two cases are mentioned by ERICHSEN, one in which the phrenic nerve was divided, and the patient died on the eighth day, of pneumonia; in the other case, incessant hiccough followed the operation, and after death the phrenic nerve was found reddened

and inflamed, having probably in some way been interfered with during the exposure of the vessel. (2) The transversalis colli and supra-scapular arteries also lie superficial to the scalenus anticus, and must be carefully preserved from injury, as they play a very important part in the collateral circulation: both these vessels run parallel with the clavicle, the supra-scapular being behind it, and the transversalis colli just above it. (3) The confluence of the internal jugular and subclavian veins is also commonly in front of the scalenus anticus. (4) On the left side the thoracic duct will be found arching downwards in front of the scalenus anticus and phrenic nerve. On the right side a corresponding structure, the right lymphatic duct, may also be found, but it is usually very small.

THIRD PART OF SUBCLAVIAN.—Right and Left.

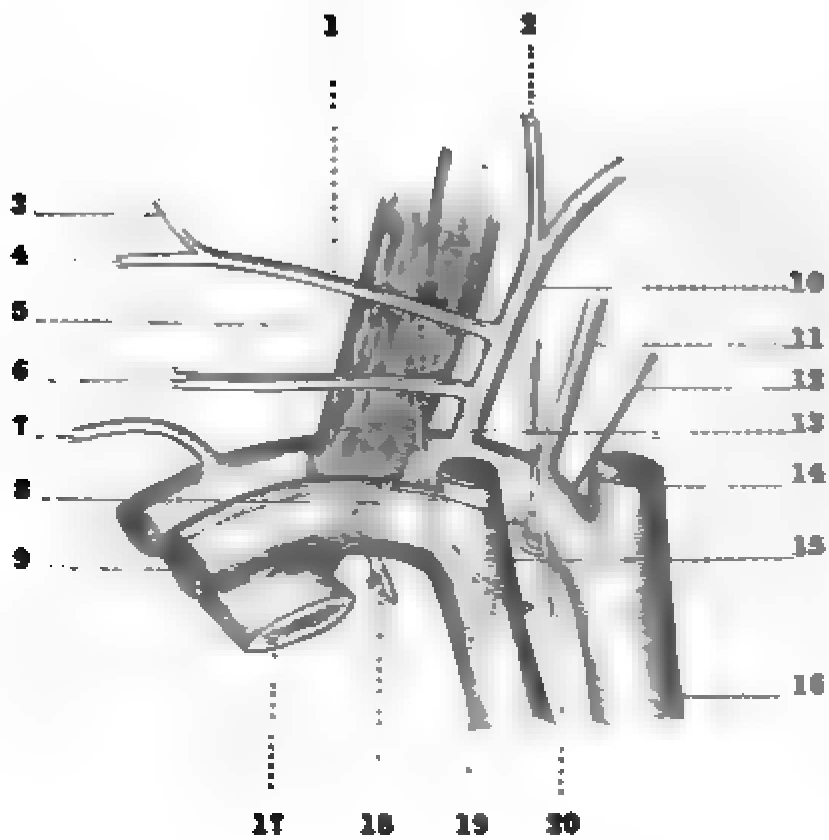
This is the part most frequently ligatured, because—(1) It is the most superficial part; (2) it is the longest part; (3) it is usually free from branches; (4) the first rib is interposed between it and the pleura, and, by passing the needle as the artery lies on the first rib, we avoid wounding the pleura, and will also usually avoid coming into contact with any abnormal arterial branches—as these usually arise close to the outer edge of the scalenus anticus. It extends from the outer edge of the scalenus anticus muscle to the lower border of the first rib, and is contained in a small triangular space, the lower and smaller of the two divisions of the posterior triangle, bounded by the sterno-mastoid in front, the clavicle below, and the posterior belly of the omo-hyoid above (see Fig. 14).

Relations.—In *front*—(1) Skin, superficial fascia, platysma, and deep cervical fascia. (2) A plexus of veins formed by the external jugular and its tributaries in this region, viz., supra-scapular, transversalis colli, and frequently also a communication from the anterior jugular, and another from the cephalic vein. (3) The descending branches of the cervical plexus of nerves. (4) Nerve to the subclavius. (5) Clavicle and subclavius muscle. (6) The supra-scapular artery. (7) The subclavian vein, but at a much lower level. *Above*—(1) The cords going to form the brachial plexus. (2) The posterior belly of the omo-hyoid. *Behind*—The scalenus medius. *Below*—The first rib, and partly also the nerve trunk formed by the union of the eighth cervical and first dorsal nerves. The same nerve cords

Fig. 13.

SUBCLAVIAN VESSELS

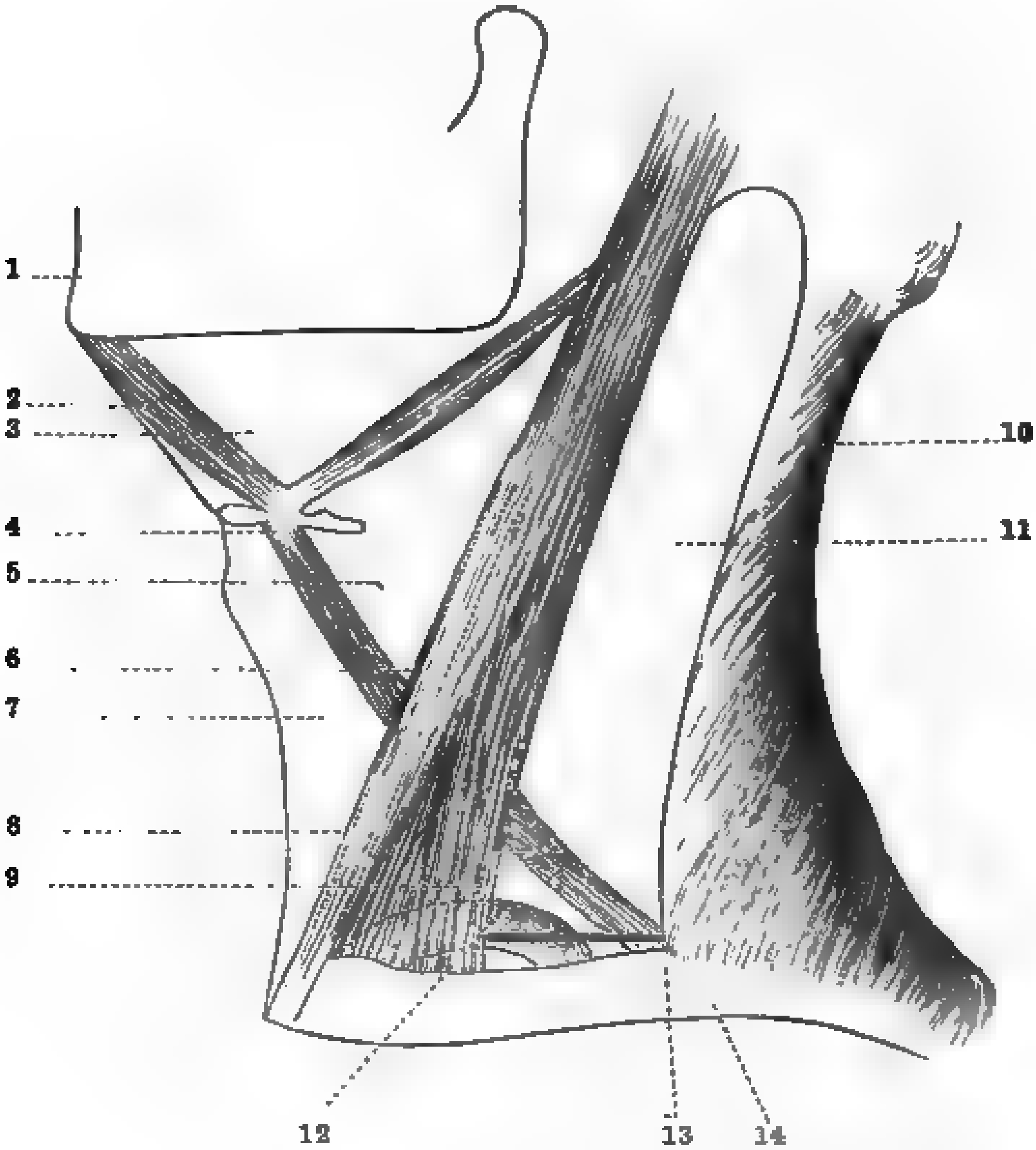
(After TURNER.)



1. Transversalis Colli.
2. Ascending Cervical.
3. Superficialis Colli.
4. Posterior Scapular.
5. Scalenus Anticus.
6. Supra-Scapular.
7. Posterior Scapular (usual origin).
8. Deep Cervical.
9. Subclavian Vein.
10. Inferior Thyroid.
11. Vertebral.
12. Recurrent Laryngeal.
13. Thyroid Axis.
14. Common Carotid.
15. Internal Mammary.
16. Innominate Artery.
17. First Rib.
18. Superior Intercostal.
19. Phrenic.
20. Vagus.

Fig. 14.

INCISIONS FOR SUBCLAVIAN AND CAROTID ARTERIES.



1. Jaw.
2. Digastric.
3. Submaxillary Triangle.
4. Omo-Hyoid.
5. Superior Carotid Triangle.
6. Incision for Carotid.
7. Inferior Carotid Triangle.
8. Sterno-Mastoid.
9. Posterior Triangle (lower part).
10. Trapezius.
11. Posterior Triangle (upper part).
12. Subclavian Artery (third part).
13. Incision for Subclavian.
14. Clavicle.

also lie behind it. The artery is sometimes described as lying in the lower part of a little triangle formed thus—internally it is bounded by the outer margin of the scalenus anticus, and externally by the scalenus posticus, the convergence of these two muscles forming the apex of the triangle, the base being formed by the first rib, on which the vessel rests (SPENCE). In the same triangle, above and behind the artery, are the cords going to form the brachial plexus.

THE OPERATION.

The **patient** should be in the recumbent position, with his shoulders supported by pillows, his head thrown backwards and his face turned to the opposite side, while the arm of the affected side is to be depressed as much as possible so as to lessen the depth of the wound. The **Surgeon** stands in front of the shoulder on which he is to operate.

Superficial Guide.—The vessel lies beneath the most prominent part of the clavicle, and it is important to remember that, by pressing the thumb or a padded key firmly downwards, inwards, and backwards, towards the first rib, about half-an-inch to the inner side of the middle of the clavicle, or just outside the sterno-mastoid, the vessel may be compressed during life, and the circulation through the upper limb entirely commanded: it is best carried out when the arm is well drawn down. **Incision.**—With the inner side of the left hand, draw down the skin over the clavicle for about one inch, and cut *along the bone* for three or four inches, beginning over the clavicular origin of the sterno-cleido-mastoid and ending at the trapezius (see Fig. 14). By drawing down the skin in this manner, one is less likely to cut the external jugular vein, which may be found in any part of the base of the posterior triangle, and perforates the deep fascia about half-an-inch above the clavicle, and is not, therefore, displaced downwards with the skin. This incision corresponds to the middle third of the clavicle, or base of the posterior triangle. In some cases, it may be advisable to make another incision, two inches in length, along the outer edge of the sterno-mastoid joining the former incision nearly at a right angle, more especially in cases where the shoulder cannot be depressed—in very fat people, or those with short thick necks. It is better, however, *not* to make this incision, if possible, but rather to extend

the first incision inwards, or even to divide a portion of the sterno-mastoid or trapezius. **Parts cut through.**—While the skin is tense over the clavicle, there is divided *on* the bone—(1) Skin. (2) Superficial fascia. (3) Platysma. (4) Superficial nerves and vessels—the nerves are the descending branches of the cervical plexus; the vessels are chiefly the tributaries of the external jugular vein, which, at this point, usually form a venous plexus in front of the subclavian artery. The external jugular vein should be now exposed and saved by drawing it inwards or outwards according to circumstances; but, if too much in the way, it should be secured by two ligatures and divided between them. This vein often lies at the inner end of the incision, close to the edge of the sterno-mastoid, and *on* the scalenus anticus. When the tension is taken off, and the wound moved a little above the clavicle, we next divide with care, on a director, if thought necessary, (5) the deep fascia in the middle of the wound—that part of the cervical fascia which binds down the posterior belly of the omo-hyoid to the clavicle. Next, seek for the interval between the omo-hyoid (posterior belly) and the clavicle which will probably be about an inch in extent, but may be more or less. If the omo-hyoid presents itself in the wound in the natural course of events, good and well; but, if not, it is *not* necessary to search for and expose it. The knife must not be allowed to pass beneath the clavicle, lest the subclavian vein or the supra-scapular vessels be injured. Take care also of the transversalis colli artery, as both it and the supra-scapular are important agents in the collateral circulation; and, besides, if the supra-scapular be injured, it is often difficult to secure, from the dense fascia in this situation and its being partly under cover of the clavicle. Push the omo-hyoid upwards a little, and, with the finger or the handle of the knife, scratch away any intervening areolar tissue, with a lymphatic gland and the other structures lying over the artery; then identify, either by sight or touch, the outer edge of the scalenus anticus muscle, and follow it down to its insertion into the first rib. (6) The small nerve to the subclavius muscle also crosses in front of the artery near its middle. At first sight, the division of this small nerve may seem a matter of little consequence; still, it is important to remember that it very frequently has a communication with the phrenic nerve, and may

give rise to unpleasant symptoms if it be lacerated, from the reflex irritation and the summation of the stimuli, starting from the lacerated point. **Deep Guide to the Vessel.**—Either the tubercle on the first rib at the insertion of the scalenus anticus, and the outer edge of the same muscle, when the artery will be found immediately above and a little behind it, but covered and bound down to the first rib by a sheath of dense cervical fascia. When the tip of the finger touches the tubercle, the pulp of the finger will rest on the artery (SPENCE); or, the three white cords going to form the brachial plexus, seen at the outer end of the wound, and which are placed above and a little behind the artery—the artery being between them and the first rib. To distinguish the artery from a large nerve trunk on the uninjected dead body, press the structure firmly with the finger against the first rib, when, if it is a nerve, it will retain its rounded form, while the artery will flatten out and become slightly concave. (7) Open the sheath, and with the forceps and director clear the vessel, and pass the aneurism needle from *above*, in order to avoid the nerves going to form the brachial plexus—one of which is far more liable to be included in the ligature than the vein is to be injured, which is to the front of and considerably below the artery. Still, it is but right to state that many Surgeons recommend that the ligature should be passed from below upwards. The needle most suitable for passing the ligature is "a common aneurism needle with a considerable curve" (BELL). Some prefer the doubly-curved rectangular or helix needles, introduced by DUPUYTREN, of which two are required—one for each side. It should be passed as low as possible, as the vessel lies *on* the first rib. It is advised, in cases where it is impossible to ligature the artery for want of space, to cut through the clavicle, provided it does not form part of the wall of the aneurism. One of the principal causes of death after ligature of the subclavian is septic inflammation, starting in the areolar tissue, and spreading to the anterior mediastinum, pericardium, and pleura. This is due to the opening up of the layers of fascia prolonged from the neck into the thorax, and more or less fixed to the inner side of the first rib, and partly forming a roof to the pleural cavity. The opening up of this roof is the more likely to happen if the artery be tied anywhere else than *on* the first rib. In dressing the

wound afterwards, a drainage tube must be used with great caution, its free end being protected from pressure lest the other end ulcerate its way into the artery. It must be removed in from thirty-six to forty-eight hours.

NOTE.—(1) In thick-set, short-necked persons the artery is usually deeply seated; it may be below the level of the clavicle, or but slightly above it. (2) In thin, long-necked persons its course is usually high, and, therefore, is much more easily reached and ligatured. (3) The clavicle in some cases is very much curved. When this is the case, the depth of the vessel from the surface is increased, and is therefore more difficult to ligature. An aneurism in the axilla will produce the same effect, by raising the clavicle, and will complicate the operation considerably, as the shoulder cannot in this case be depressed; a similar result may be produced by emphysema of the lung. (4) The artery may pass in front of, or through the anterior scalenus; the clavicular head of the sterno-mastoid, instead of being confined in its origin to the inner third of the posterior surface of the clavicle, may pass beyond its usual limit outwards along the clavicle, and conceal the artery; and the trapezius may also pass further inwards than it usually does, and overlap the vessel. In five per cent. of the cases, the omo-hyoid arises from the middle third of the clavicle, and, therefore, covers the artery. When this condition is encountered the muscle must be divided in order to reach the vessel. (5) The posterior scapular artery frequently, and sometimes the supra-scapular, may spring from this part. (6) The external jugular vein should lie just external to the sterno-mastoid; but, very frequently, it is more external, and passes beneath the deep fascia just above the middle of the clavicle, crossing the third part of the subclavian artery, and emptying itself into the subclavian vein. While it lies over the artery it receives the supra-scapular and transversalis colli veins, and in this region also communicates with the anterior jugular and cephalic veins. In this way a plexus of veins is formed in front of the artery. If any of the large venous trunks must be cut in the operation, a double ligature should be first applied and the vein divided between. The subclavian vein may rise as high as the level of the clavicle, or may lie with the artery beneath the anterior scalenus. (7) A cord formed by the eighth cervicle and first dorsal

nerves lies immediately behind the subclavian artery—or may be between it and the first rib—and is, therefore, specially liable to be included in the ligature, or even to be tied instead of the artery—mistakes committed by several eminent Surgeons. (8) In some cases the supra-scapular artery is much enlarged, and has been mistaken for the subclavian. (9) Aneurism of the transversalis colli may simulate subclavian aneurism. (10) The artery may be pushed forwards by a supernumerary cervical rib, or an exostosis springing from the first rib, conditions which at first sight may simulate subclavian aneurism.

RÉSUMÉ of the chief points in this operation:—

1. Make the incision opposite the middle third of the clavicle in the way directed.
2. Make sure of the safety and position of the external jugular and other large veins. The external jugular will be found by scratching through the deep fascia, close to the clavicle, with the handle of the knife.
3. Define the edge of the scalenus anticus, and use the tubercle at its insertion as guide to the vessel.
4. Make a small opening in the sheath and clear the vessel thoroughly.
5. Pass the needle from above.
6. Take care not to include the cord formed by the eighth cervical and first dorsal nerves.

The anatomical guides to this operation are well marked. We have first the outer edge of the sterno-mastoid, which guides to the outer edge of the anterior scalene; then the anterior scalene itself, and lastly the tubercle at its insertion into the first rib; we have also the cords going to form the brachial plexus.

Collateral Circulation, when the subclavian is tied in its second and third parts (see Fig. 12)—1. The supra-scapular (15) from thyroid axis (first part of the subclavian) anastomosing with the dorsalis scapulæ branch of the subscapular (25) (from third part of axillary). 2. The posterior scapular branch of the transversalis colli (14), of thyroid axis, anastomosing with the subscapular (25) and circumflex branches (22) of axillary. 3. Internal mammary (29) ˋ›m first part of the subclavian, the superior intercostal (18) and

the aortic intercostals (30), anastomosing with the long and short thoracics of axillary artery (26, 21), and the deep epigastric (28).

IRREGULARITIES.—The right subclavian may spring as a separate trunk from the arch of the aorta, and when it does so, the first part is much deeper than usual. It may pass in front of or through the fibres of the scalenus anticus; and its point of origin varies according to the point of bifurcation of the innominate. When it springs directly from the arch it may be the first, second, third, or even the fourth branch. When it is the first it occupies the position of the innominate; when it is the second or third, it usually passes behind the right carotid to gain its usual position; and when it is the last branch it may pass behind the œsophagus, or between it and the trachea, to reach its ordinary position. When it passes in front of or behind the œsophagus, there is a great risk of sharp foreign bodies caught in the œsophagus, *e.g.*, fish bones, ulcerating through into the subclavian and causing fatal hæmorrhage. The left subclavian is sometimes joined with the left common carotid at its origin. An instructive case is related by Mr HOLMES, where, in a case of aneurism of the arch of the aorta, the pulsation in the right carotid was normal, but the pulse at the right wrist was obliterated. The explanation was that, in this case, the subclavian arose as the last branch from the arch, and in order to reach its usual position it passed between the arch and the spine, against which the aneurism compressed and obliterated it.

Treatment of Subclavian Aneurism.—1. *Medical and dietetic*, combined with rest, etc. 2. *Surgical measures;* as a rule all operative measures are more or less dangerous or uncertain—(*a*) In aneurism of *first* or *second* parts, pressure on the vessel at the distal side of the tumour against the first rib may be tried; (*b*) in the same condition, ligature of the third part above or below the clavicle may be tried—BRASDOR'S plan, or distal ligature; (*c*) ligature of the innominate, if the aneurism be limited; and (*d*) or amputation at the shoulder joint and tying the artery on the face of the stump (FERGUSSON). In aneurism of the *third* part we may—(*a*) Ligature the first part, using ox aorta or kangaroo tail tendons, so as rather to compress the vessel than to divide its coats; (*b*) direct pressure on the tumour with refrigeration; and (*c*) amputation at shoulder joint. Other means, equally uncertain and dangerous, such as

galvano-puncture, manipulation, and introduction of foreign bodies have been tried.

BRANCHES OF THE SUBCLAVIAN.

OF THE FIRST PART.—I. **Vertebral.**—It arises from the upper and back part of the artery, passes up behind the internal jugular vein, between the longus colli on the inner side, and scalenus anticus on the outer side, to the foramen in the transverse process of the sixth cervical vertebra; sometimes it enters as low as the seventh, or yet again may enter as high as the fifth. The left vertebral is usually the larger. It is crossed by the inferior thyroid artery on both sides, and on the left side, in addition, by the thoracic duct. In the foramen it is surrounded by a plexus of sympathetic nerves, having its own vein in front, and the trunks of the cervical nerves behind it. This vessel was first ligatured by Dr SMYTH of New Orleans, in 1864; and, more recently, the operation has been recommended by Dr ALEXANDER of Liverpool, in epilepsy.

We append Dr SMYTH's description of the operation as performed by himself:—"The head of the patient being thrown back and slightly turned to the left, an incision two inches in length was made along the posterior border of the sterno-mastoid muscle, commencing at the point where the external jugular vein crosses this muscle, and terminating a little below the clavicle, the edge of the muscle being exposed and drawn to the inner side, the prominent anterior tubercle of the transverse process of the sixth cervical vertebra was readily felt and taken for a guide. Immediately before this, and in a vertical line with it, lies the artery. A layer of fascia was now divided, some loose cellular tissue, with lymphatics, and the *ascending cervical* artery, were pulled to the inner side, and a separation was made between the scalenus anticus and longus colli muscles just below their insertion into the tubercle, when the artery and vein became visible, the latter was drawn to the outer side (this is important), and the needle passed around the former, from without inwards."

In performing this operation care must be taken not to mistake the inferior thyroid artery for the vertebral. Immediate contraction of the corresponding pupil is often noticed when the vessel is tied;

this is no doubt due to some interference with the sympathetic filaments on their way to supply the dilator pupillæ. Wounds of the vertebral are very often mistaken for wounds of the common carotid, because pressure *below* the level of the "carotid tubercle" arrests the flow through *both* vessels, and therefore arrests the bleeding from the wound, and has led in many cases to the ligature of the carotid, whereas the vertebral was the vessel at fault.

Above the upper border of the axis the artery passes outwards and upwards to reach the foramen in the transverse process of the atlas; after passing through this it lies in a deep groove on the upper surface of the posterior arch of this bone (see "Sub-occipital Triangle"), pierces the posterior occipito-atloid ligament and dura mater, enters the skull through the foramen magnum, winds round the medulla to its anterior aspect, and, at the lower border of the pons, unites with the vessel of the opposite side to form the basilar. In the groove on the posterior arch of the atlas the *sub-occipital nerve* lies beneath it, and in the skull it lies between the hypo-glossal and the anterior root of the first cervical nerve.

On the **left side** the operation is more difficult and dangerous than on the right, on account of the presence of the thoracic duct. This structure rises in the neck as high as the sixth cervical vertebra, passing outwards *behind* the internal jugular vein and *lying on* the vertebral artery and vein (or very frequently between them) the anterior scalene, the supra-scapular and transversalis colli arteries, and phrenic nerve. It then curves downwards and inwards to enter the left subclavian vein at its junction with the left internal jugular.

NOTE.—(1) The prominent anterior tubercle of the transverse process of the sixth cervical vertebra is known as the "*carotid tubercle*" of CHASSAIGNAC, and by some Surgeons is used as the "deep" guide in ligature of the common carotid artery as well as in ligature of the vertebral; it is also, in Dr DROBECK's method, used as the guide for the inferior thyroid; the artery arches upwards round this process, and is about one inch above it. It is about two inches above the clavicle, or on a level with the cricoid cartilage.

(2) The *sub-occipital nerve* is the undivided posterior primary division of the first cervical nerve. This nerve communicates with the great occipital, the vagus, and the hypo-glossal; when the vertebral

artery is diseased, therefore, it may press on these various nerves, causing pain in the back of the head, along the great occipital, and has also been said to affect speech from pressure on the hypo-glossal in the skull, leading to partial paralysis of the muscles of the tongue.

II. **The Thyroid Axis.**—This is a short trunk which arises from the anterior and upper part of the vessel, and very soon divides into three branches—(*a*) **Inferior Thyroid**, which passes upwards and inwards in *front* of the vertebral artery, recurrent laryngeal nerve, and longus colli muscle, but *behind*, the carotid sheath and its contents, and the gangliated cord of the sympathetic, the middle cervical, or thyroid, ganglion usually resting upon it. It takes a flexuous course to the inferior angle of the thyroid body, which it enters on a level with the body of the fifth cervical vertebra, the recurrent laryngeal nerve at this point often passing between its terminal branches; at first it passes vertically upwards to a point just above the "carotid tubercle," and after that it curves inwards obliquely to the thyroid body. If this branch be ligatured in its **oblique part**, as it passes behind the carotid sheath, the incision and the structures divided will be nearly the same as in ligature of the common carotid at the lower part of the neck, the necessary modifications being evident. As the omo-hyoid partially conceals the vessel, it must be drawn aside or divided; when this is done, look for the artery between the trachea and the œsophagus on the inner side, and the carotid sheath with its contents on the outer side. In performing this operation great care must be taken not to injure the descendens noni, or the recurrent laryngeal nerve. In excision of the thyroid body, this vessel requires to be ligatured as it enters the inferior angle of the gland. The **branches** of the inferior thyroid artery are—(1) Ascending cervical; (2) inferior laryngeal branch; (3) œsophageal; (4) tracheal. It may also be ligatured in its first or **vertical portion**, by an incision two or three inches in length along the posterior border of the sterno-mastoid (DROBECK); the incision begins about half-an-inch above the clavicle. Take care of the external jugular vein and the phrenic nerve; the trunk of the artery is found near the inner border of the anterior scalene. The deep guide is either the "*carotid tubercle*," or the ascending cervical branch, which lies between the scalenus anticus and the

rectus anticus major, and which, when found, will lead to the parent trunk. (*b*) **Transversalis Colli**—Passes outwards in front of the scalenus anticus and phrenic nerve, and beneath the sterno mastoid, into the posterior triangle of the neck, where it passes in front of the cords going to form the brachial plexus, and ends there by dividing into superficial cervical and posterior scapular arteries. Aneurism of this branch may simulate subclavian aneurism. (*c*) **Supra-scapular,** or **Transversalis Humeri**—This vessel is on a lower level than the last, and runs outwards in front of the scalenus anticus and phrenic nerve, but behind the clavicle and the omo-hyoid to the upper border of the scapula. In some rare cases this branch is much enlarged, and has been mistaken for the subclavian artery itself.

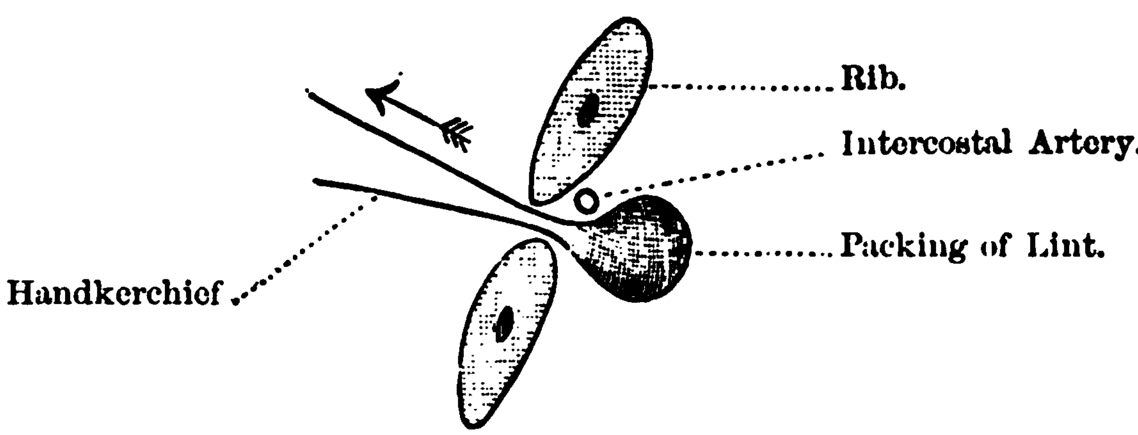
III. **Internal Mammary.**—This vessel arises from the anterior and lower part of the subclavian, and passes downwards behind the inner end of the clavicle, and the beginning of the right innominate vein, and enters the chest between the first rib and the pleura; as it is about to enter the chest, it is crossed by the phrenic nerve, and covered by the internal jugular and subclavian veins. If this vessel were to be tied at its origin, it should be borne in mind that its anterior relations are precisely similiar to those of the first part of the subclavian (*see above*). For the rest of its course it lies fully half-an-inch external to the margin of the sternum, and in the interval between the sixth and seventh costal cartilages it ends by dividing into the *musculo-phrenic* and *superior epigastric arteries.*

Relations.—In *front,* the internal mammary is covered by—(1) The skin, superficial and deep fascia; (2) pectoralis major; (3) anterior intercostal membrane; (4) internal intercostal muscle; (5) costal cartilages. It *lies on*—(1) Triangularis sterni; (2) costal pleura; (3) the terminations of the intercostal nerves. The *left* internal mammary is usually described as being one of the contents of the anterior mediastinal space, but such is not the case, as in no part of its course does it lie within that space (CUNNINGHAM). For the purpose of ligature the vessel may be reached by an oblique **incision** downwards and outwards from the side of the sternum, the centre of the incision being half-an-inch from that bone; then by dividing the various muscular and fascial layers already indicated,

the artery, with its accompanying veins, can be readily exposed. The vessel may also be exposed by a transverse or vertical incision, and is most easily reached in the second space. In cases, however, of hæmorrhage from the artery, the result of a wound, the operation of securing the vessel may be more difficult, but the bleeding may be readily controlled by compression, as in the case of an intercostal artery; a small bag of muslin or a fine silk handkerchief, being introduced through the wound, is stuffed with lint or a piece of sponge, and then withdrawn so as to effectually compress the vesse against the costal cartilages (Fig. 15).

Fig. 15.

INTERCOSTAL HÆMORRHAGE.



When the hankerchief is pulled outwards, in the direction of the arrow, the round ball presses on the artery and stops the bleeding.

OF THE SECOND PART.—The superior intercostal artery, and arising in common with it is the **profunda cervicis** branch, which passes backwards between the neck of the first rib and the transverse process of the seventh cervical vertebra, and ascends in the neck between the complexus and the semi-spinalis colli, supplying these muscles and anastomosing with the vertebral and **princeps cervicis** branch of the occipital artery. On the left side as already mentioned, the superior intercostal arises from the first part of the subclavian. In either case it descends into the thorax in front of the neck of the first rib, and gives off the posterior intercostal arteries to the first and second spaces, anastomosing with the first aortic intercostal and the internal mammary. The inosculation between the *profunda* and the *princeps cervicis* is an important agent in re-establishing the circulation after ligature of the common carotid.

CHAPTER VII.

CAROTID ARTERIES.

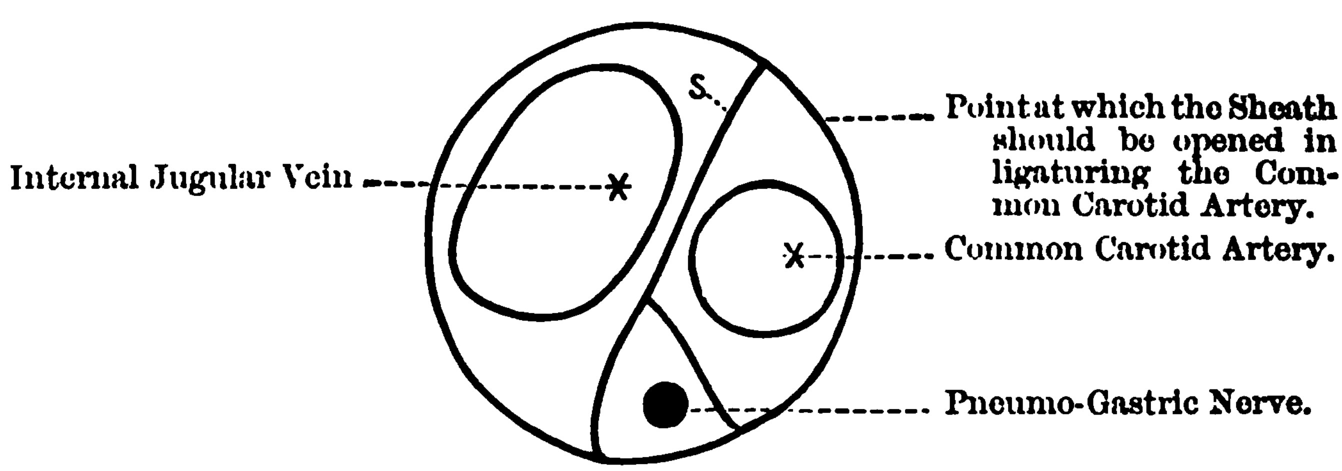
Common Carotid Artery.—Aneurism of this vessel presents as a pulsating tumour between the two heads of the sterno-mastoid, more or less elongated in the vertical direction, with a bruit propagated upwards, and not towards the axilla, and gives rise to *special pressure symptoms*:—for instance, if the aneurism be situated near the bifurcation of the vessel (where it usually occurs), there is a constant hacking cough due to pressure on the superior laryngeal nerve; if it be placed lower down we may get spasm of the glottis from pressure on the recurrent laryngeal nerve. On account of the dense cervical fascia the aneurism tends to press inwards, and may simulate abscess of the tonsil or pharynx, but is more rounded and circumscribed than abscess, and the swelling will pulsate. There may also be serious dyspnœa and difficulty in deglutition from direct pressure, and also from irritation of the pharyngeal plexus. Aneurism of this vessel occurs earlier in life than most aneurisms, and as often in women as in men; it is most common on the right side and usually at the bifurcation, as at this point the pressure is greater than elsewhere. To compress this vessel during life one may—(1) squeeze it laterally by placing the thumb at the anterior border of the sterno-mastoid, and the next three fingers at the posterior edge: in this way the vagus escapes pressure; (2) directly backwards against the "carotid tubercle." In using this second method pressure must be made on a level with the cricoid cartilage (which corresponds to the level of the "carotid tubercle"), because if below this point the vertebral will be compressed as well. This is important, because wounds of the common carotid are very common in civil practice, and must be distinguished from wounds of the vertebral, and vice versa.

Origin.—On the *right* side in the bifurcation of the innominate artery opposite the sterno-clavicular articulation. On the *left* side it springs directly from the arch of the aorta. **Extent.**—From behind the sterno-clavicular articulation to a point a little higher than the upper margin of the thyroid cartilage, where it divides into internal and external carotids. **Course.**—Its course is indicated by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process.

The artery, together with the internal jugular vein and vagus nerve, are included in a common sheath derived from the deep cervical fascia, although each structure lies in a separate compartment; the septa are comparatively strong, especially that between

Fig. 16.

TRANSVERSE SECTION OF LEFT CAROTID SHEATH.



S. Septum between the Artery and Vein.

the vein and the artery. This is important, because the compartment containing the artery may be opened without interfering with those containing the vein and nerve, and in this way the vein, which is about twice the size of the artery, and often overlaps it, is prevented from bulging unduly over that vessel during the operation. In the sheath the artery is the most internal, the vein most external, and the nerve behind and between (Fig. 16).

Before describing the operation itself, we will state very briefly the chief relations of the sheath to the surrounding parts.

As high as the **Cricoid Cartilage** it is deeply placed, and is *covered by*—(1) The common investments (*i.e.*, skin and superficial

fascia, platysma and deep fascia). (2) Sternal head of sterno-mastoid. (3) Sterno-hyoid. (4) Sterno-thyroid. (5) Crossed by omo-hyoid. (6) Above this point it enters the carotid triangle, is covered by the common investments of the parts overlapped by the sterno-mastoid, and crossed about the point commonly chosen for the application of a ligature by the sterno-mastoid artery from the superior thyroid. It is also crossed by (7) three veins—superior and middle thyroids, and the anterior jugular. (8) The descendens noni lies *on* (sometimes *in*) the sheath. (9) In front of the superficial part there are some lymphatic glands; it is important to remember this, as a gland may be mistaken and cleaned for the artery. Further, these glands are apt to suppurate, and may simulate aneurism. (For the Diagnosis between Aneurism and Abscess, see page 6.) It is usually slightly overlapped by the sterno-mastoid at its upper part. *Behind* the sheath is—(1) The gangliated cord of the sympathetic; (2) the recurrent laryngeal nerve crossing obliquely inwards behind the sheath; (3) longus colli; (4) rectus capitis anticus major; and behind these (5) the transverse processes of the cervical vertebræ, against which the vessel may be compressed during life. (6) The inferior thyroid artery also crosses obliquely inwards behind both the sheath and the gangliated cord of the sympathetic. (See the "Branches of Subclavian.") (7) Behind the deep part of the sheath are some lymphatic glands. To its *inner side* we have—(1) The larynx and trachea. (2) Pharynx and œsophagus. (3) Thyroid body. (4) Recurrent laryngeal nerve and inferior thyroid artery. To the *outer side*, a chain of lymphatic glands and the scalenus anticus. It should be noted, however, that though the glands at the lower part of the neck are behind the sheath, yet at the upper part many glands lie in *front* of the artery; it is important to keep this in mind as these glands may undergo chronic inflammation and suppuration, and closely simulate an aneurism. The above are the chief relations of the carotid sheath.

To assist the memory, note the following points in regard to the relations of the artery itself:—1. That there are four muscles in front of it, viz., sterno-mastoid, sterno-hyoid, sterno-thyroid, and omo-hyoid. 2. That there are four veins in relation to the artery—two jugular and two thyroid, three of these cross it, and one (the internal jugular) lies to its outer side. 3. That there are four

nerves in relation to it—*above*, the descendens noni; *behind*, the gangliated cord of the sympathetic; on the *inner* side, the recurrent laryngeal (at its lower part); on the *outer* side, the vagus. 4. There are four chief things to its inner side—the air passages, the food passages, thyroid body, and recurrent laryngeal nerve with the inferior thyroid artery.

In the living body it should be remembered that the vessel is overlapped throughout its entire extent by the sterno-mastoid, as this muscle does not pass in a straight line from the sterno-clavicular articulation to the mastoid process, but takes a curved course, the convexity of the curve being directed towards the middle line of the neck. This curve is maintained by a process of deep cervical fascia attached on the one hand to the deep surface of the sterno-mastoid and on the other to the angle of the lower jaw, for as soon as it is cut the anterior edge takes a straight direction (Ellis).

It may be necessary to ligature this vessel for a wound, either of itself or its branches, for aneurism, for epilepsy, for erectile and pulsating tumours of the orbit and skull, or cirsoid aneurism of the scalp; it has also been ligatured for wounds in the mouth and ulceration of the tongue. As it gives off no branches it may be tied at any part of its course, but it is better to avoid tying it either close to its origin or to its termination—at its *origin*, on account of its great depth, and especially on the left side where the internal jugular vein is in front and the thoracic duct behind it; at its *termination*, because here there is a large plexus of veins in front of it. If for a wound, it must be tied on both sides of the bleeding point and then divided between; if for a wound of its branches, or pulsating tumour higher up, it should be tied in the most accessible position—above the omo-hyoid; if for an aneurism, the point of ligature will depend on its position, *e.g.*, in aneurism of the upper part, the Hunterian operation may be used, while in aneurism low down we may use the method suggested by Brasdor. Ligature of the vessel for cirsoid aneurism of the scalp ("aneurism by anastomosis" of some), a similar condition of the orbit, or other forms of pulsatile simple tumours of the orbit and scalp, cannot be regarded as a necessary or even justifiable operation, since Dr John Duncan has proved the safety and certainty of cure by electrolysis.

LIGATURE ABOVE THE OMO-HYOID.

The **patient** should be placed in the recumbent position, and his shoulders raised by means of pillows, the head being thrown back a little, and the face turned towards the opposite shoulder, in order to make the sterno-mastoid tense and prominent, and the angle of the jaw turned up somewhat. The neck should be compressed at the lower part, in order to make the superficial veins, as the anterior and external jugulars, turgid, and their course noted, so that they may be avoided as much as possible in making the necessary incision. The **Surgeon** should stand on the same side as the vessel about to be ligatured, and most conveniently behind the shoulder for the left side, but in front of the right, or in both cases facing the side of the patient's neck.

Superficial Guide.—The line marking its course, or the anterior border of the sterno-mastoid. **Incision.**—With the line of the vessel in mind, make an incision three inches in length, so arranged that its centre shall be on a level with, or rather higher than, the cricoid cartilage—the point usually selected for ligature above the omo-hyoid (see Fig. 14). The upper part of this incision will be a few lines *nearer* the middle line of the neck than the *reputed* anterior margin of the sterno-mastoid, this muscle diverging from the artery as it rises higher in the neck; this, however, is only the case when the process of deep cervical fascia, already mentioned, is divided, and therefore must not be looked for out of the dissecting room. By this incision we divide—(1) the skin, (2) superficial fascia, (3) platysma. (4) Then cut through the deep fascia and expose the edge of the sterno-mastoid, and draw it aside with blunt hooks, the head being previously turned a little towards the same shoulder and flexed by the assistant, in order to relax its fibres. (5) Expose the omo-hyoid by cutting through a dense fascia covering it and the other muscles and carotid sheath. It is of importance to note that at this part of its course there is usually a large venous plexus in front of the vessel formed chiefly by the superior thyroid veins with communications from the lingual, facial, anterior, and external jugulars. (6) Draw aside the lateral lobe of the thyroid body which is now exposed, and look for the **deep guide** to the vessel, viz., the angle formed by the anterior belly of the omo-hyoid with the anterior

border of the sterno-mastoid — the artery bisecting this angle. Draw the muscle inwards with a blunt hook, and then expose the sheath fully, by carefully turning aside any intervening structures with the *handle* of the knife, using the blade as little as possible, in order that the descendens noni nerve and its communications, and sterno-mastoid branches of the superior thyroid artery, be not injured. Open the *inner* compartment of the sheath well to the tracheal side, since the greater part of the sheath, as thus exposed, is occupied, in the living body, by the internal jugular vein (see Fig. 16). Then clear the artery very thoroughly from the special areolar sheath surrounding it, till the white external coat comes into view, and pass the ligature (without using force) from the *outer* side to avoid the risk of wounding the internal jugular vein or including the vagus, holding the other edge of the opening in the sheath with a pair of artery forceps to steady it during the passage of the ligature.

RÉSUMÉ of the principal steps in this operation:—

1. Centre of the incision to be opposite the cricoid cartilage, not too far forward, lest the anterior jugular be cut.
2. Expose the anterior edge of the sterno-mastoid, and secure sterno-mastoid artery.
3. Expose the upper edge of the anterior belly of the omo-hyoid, watching for the venous plexus, sterno-mastoid artery, and descendens noni nerve. Now flex the head, and,
4. With a finger in the wound, press towards the transverse processes of the vertebræ, and feel the artery in the angle between the omo-hyoid and the sterno-mastoid, rolling beneath the finger.
5. Open the *common* sheath well to the *inner side*, and, if necessary, push the internal jugular outwards, or compress it at the upper angle of the wound to empty it.
6. Open the *special* cellular tissue sheath of the artery, and clear it till the white external coat is seen, and then pass the needle from the outer side.

LIGATURE BELOW THE OMO-HYOID.

Right Side.—The position of the patient and the Surgeon are the same as for the higher operation. If we wish to ligature the vessel below the omo-hyoid, it is necessary—(1) That the incision be extended further down along the anterior edge of the sterno-mastoid, which must be drawn well outwards, after having divided its sternal head. An **incision** three inches long commencing a little above the level of the cricoid cartilage, and extending to the episternal notch, will be found sufficient; sometimes an angular incision is used, corresponding to the lower two inches of the sterno-mastoid, and the inner two inches of the clavicle. (2) To divide the fascia binding the omo-hyoid to the muscles near it, and draw it upwards. (3) Draw the sterno-mastoid outwards, the sterno-hyoid and sterno-thyroid muscles inwards, or, if necessary, divide the sterno-hyoid, and the carotid sheath is now exposed. Proceed as in ligature above the omo-hyoid, bearing in mind the complicated relations of the parts. There is a venous plexus in front of the vessel formed chiefly by the middle thyroid veins, with communications from the anterior and external jugulars; the chief trunks must be carefully avoided, as well as the ansa hypoglossi and its branches. On the **left side** the artery springs from the arch of the aorta, but beyond the sterno-clavicular articulation, its relations are almost the same as those of the vessel on the right side, with the following differences:—(1) It is more deeply placed, as the right arises from the innominate artery which lies in front of the trachea, while the left lies rather behind that structure. (2) The internal jugular vein and the pneumogastric nerve are often placed in front of the artery in the lower third of the neck. This makes clearing the vessel for the passage of the ligature more difficult on the left side; on the right side it is easy, because the vein and nerve incline away from the artery at its lower part, but on the left side the vein bulges right over the vessel, and in the living subject complicates the operation considerably. (3) Being deeper it is nearer the œsophagus, which lies on its inner side. (4) Low down, the thoracic duct lies to its outer side. Otherwise the operation for ligature of the vessel on the left side is similar to the corresponding operation on the right side.

After the operation the patient should be placed in bed with the head and shoulders raised. His head should be bent a little forwards to relax the parts, and fixed in that position by a circle of bandage round it, with strips passing from it to be fixed to a broad band round the chest. An opiate, or a mixture containing hydrocyanic acid, may be necessary to allay laryngeal irritation.

RÉSUMÉ of this operation:—

1. An incision three inches long is made from a little above the cricoid cartilage to the episternal notch.
2. Expose the sterno-mastoid and divide its sternal head and draw it outwards, and draw the omo-hyoid upwards.
3. Secure the anterior jugular and middle thyroid veins.
4. Expose the sterno-hyoid and draw aside or divide it; the sterno-thyroid will not require division, as a rule.
5. Press a finger backwards towards the transverse processes of the cervical vertebræ and feel for the "carotid tubercle;" the artery will be felt rolling under the finger.
6. Divide the *common* sheath and clear the artery from its *special* cellular tissue sheath and tie as in the high operation.

SÉDILLOT has ligatured the artery at the root of the neck by an incision between the two heads of the sterno-mastoid; the head is flexed, the two parts of the musele separated, and the vessel exposed and tied, taking special care of the vagus nerve and the internal jugular vein.

Collateral Circulation (see Fig. 12).—1. Branches of the external carotid on the side tied, anastomosing with the corresponding branches of the opposite side (4), viz.—(*a*) Facial with facial; (*b*) temporal with temporal; (*c*) occipital with occipital; (*d*) superior thyroid with superior thyroid (10). 2. Anastomoses between the internal carotids of opposite sides through the anterior segment of the "circle of Willis"—anterior cerebral of the one side, with the anterior cerebral of the other, through the anterior communicating (1). 3. Anastomoses between the subclavian and the external carotid of the side tied—(*a*) The deep cervical (11)

with princeps cervicis of occipital (6); (*b*) the vertebral (8) with the occipital (7); (*c*) inferior thyroid with superior thyroid (10). 4. Anastomoses between the subclavian and the internal carotid of the side tied, the vertebral (from subclavian) through the basilar and posterior cerebral, with posterior communicating from internal carotid, *i.e.*, through the lateral segment of the "circle of Willis" (1). 5. Anastomoses of the ophthalmic, from the internal carotid, through the "circle of Willis," with branches of the external carotid on the side tied—(*a*) Nasal of ophthalmic with angular of facial; (*b*) infra-orbital, from internal maxillary, with twigs of facial; (*c*) supra-orbital and frontal, from ophthalmic, with terminations of the anterior temporal.

The usual cause of death after ligature of the common carotid is cerebral disease induced by the operation, from the sudden interference with the cerebral circulation; the symptoms are twitchings, tremblings, convulsions, syncope, giddiness, and sometimes complete hemiplegia of the opposite side, probably due to the diminished supply of arterial blood. The softening of the brain which is apt to follow corresponds, pathologically, to gangrene in other situations; abscess in the brain has occasionally been found. In other cases drowsiness, stupor, and apoplexy supervene, probably from the venous congestion. Besides the cerebral symptoms the lungs, in many cases, appear to be affected, probably from the interference with the blood supply to the medulla oblongata, they become congested and are apt to run into a low form of inflammation, just as in injury of the trunks of the vagi. Occasionally, vascular erectile tumours are situated over the course of the carotid artery, and may indirectly communicate with it or the jugular vein: under such circumstances the diagnosis of aneurism becomes a matter of extreme difficulty.

IRREGULARITIES.—The vessel may bifurcate as low as the cricoid cartilage, or even lower, so that two trunks are met with instead of one at the usual seat of ligature. Sometimes it ascends as high as, or even higher than the hyoid bone before it divides. The carotids may arise by a common trunk, the right then passing in front of the lower part of the trachea in the neck to reach its usual situation; in such a case it would be in the way, and form a great source of danger in the operation of tracheotomy.

INTERNAL CAROTID ARTERY.

Origin.—From the bifurcation of the common carotid, opposite the upper border of the thyroid cartilage. It is deeper and further from the middle line (*i.e.*, more posterior) than the external. It is called "*internal*" because it is distributed to the interior of the cranium. The internal jugular vein, the vagus, and the sympathetic nerves have the same relation to the internal as to the common carotid artery. **Course.**—Its course is indicated by the upper part of a line drawn from the sterno-clavicular articulation to a point just in front of the lobule of the ear. The part below the posterior belly of the digastric (*i.e.*, the part in the carotid triangle) is the only accessible portion.

Relations.—In *front*—(1) Skin; (2) the superficial fascia; (3) platysma; (4) deep fascia; (5) crossed by the ninth nerve, sending down the descendens noni; (6) also crossed by the occipital artery, giving off some sterno-mastoid branches. Higher up we find (7) the parotid gland; (8) the stylo-glossus and the stylo-pharyngeus muscles; (9) the glosso-pharyngeal nerve and pharyngeal branch of vagus; (10) the external carotid artery. On the *outer side*—(1) The internal jugular vein; (2) spinal accessory nerve; (3) pneumo-gastric nerve. On the *inner side*—(1) The pharynx; (2) ascending pharyngeal artery; (3) tonsil. *Behind*—(1) The gangliated cord of sympathetic; (2) superior laryngeal nerve (internal and external branches); (3) rectus capitis anticus major; (4) further back, the cervical vertebræ. An extra-cranial aneurism of this vessel tends to bulge into the pharynx, as there is least resistance to its growth in this direction.

Incision.—With the patient and Surgeon in the same position as in ligature of the common carotid, an incision should be made in the line of the vessel along the inner edge of the sterno-mastoid muscle, from the angle of the jaw to the upper border of the thyroid cartilage. The best position for applying the ligature is about midway between the hyoid bone and the digastric. By this incision we cut through (1) skin; (2) superficial fascia; (3) platysma; and (4) deep fascia. Draw aside the sterno-mastoid, when (5) the occipital artery with its mastoid branch, and (6) the ninth nerve ·ith its descendens noni branch, are brought into view. Turn

these aside, open the sheath, clear the vessel, and pass the ligature. Great care is necessary in clearing the vessel on account of its close relation to the internal jugular vein on its outer side, the vagus nerve behind and to its inner side, and the external carotid above and somewhat to its inner side. The needle is to be passed from the outer side, *i.e.*, *from* the vein.

This is an operation rarely, if ever, performed on the living body. In cases of wound of the vessel in the neck by a stab or bullet, etc., it should, if possible, be tied at the bleeding point, but in this case, the wound is the guide. Sometimes it is very difficult to be quite sure of the position of the bleeding point, and in that case, the common carotid should be tied. In cases of intra-cranial and orbital aneurism, ligature of the common carotid is the more effectual operation. Should it be injured from the fauces, as in operations on, or in ulceration of, the tonsils, ligature of the common trunk is the proper plan of treatment.

NOTE.—The vessel lies, at this part of its course, external to the external carotid. The internal jugular vein is to its outer side, and, therefore, the aneurism needle should be passed *from* this side; further, the gangliated cord of the sympathetic and the vagus, with its superior laryngeal branch, are behind it. When one internal carotid trunk has been tied the circulation is very speedily re-established by the internal carotid, and vertebral of the opposite side, and vertebral of the same side, through the "Circle of Willis."

PECULIARITIES.—The length of the internal carotid varies according to the point of bifurcation of the common. Sometimes it springs directly from the arch of the aorta; occasionally, it is altogether absent.

EXTERNAL CAROTID ARTERY.

Origin.—At the same point as the internal. **Extent.**—From its point of origin upwards to a point opposite the neck of the condyle of the lower jaw, where it divides into temporal and internal maxillary arteries. In the child, it is smaller than the internal; but in the adult, the two vessels are almost of equal size. It is called "*external*" because it is distributed to the outer aspect of the cranium. At first it is placed on the inner side of the internal carotid, but afterwards is superficial to that vessel. **Course.**—Runs

upwards and slightly outwards, passing between the angle of the jaw and the mastoid process, lying a little to the front of the anterior border of the sterno-mastoid, very nearly corresponding to a line drawn from the front of the meatus of the ear to the cricoid cartilage, slightly arched forwards.

Relations.—In the **first part** of its course the vessel lies in the carotid triangle, and is quite superficial, being merely *covered by*—(1) Skin; (2) superficial fascia; (3) platysma, with branches of the superficial cervical, great auricular, and infra-maxillary branches of the facial nerve; (4) deep fascia; (5) lingual and facial veins, and may be slightly overlapped by the sterno-mastoid. In the **second part** of its course it is deeper, being covered by (6) the posterior belly of the digastric and stylo-hyoid muscles, and (7) crossed by the ninth nerve. In the **third part** it is still deeper, for it passes beneath the deep surface of, and enters (8) the parotid gland, and under the structures in its substance. *Behind* the vessel we have—(1) The superior laryngeal nerve with its external branch, and the structures which separate the external from the internal carotids, viz., (2) stylo-pharyngeus and (3) stylo-glossus muscles; (4) styloid process, if long (if short, we will have the stylo-hyoid ligament); (5) glosso-pharyngeal nerve, and (6) pharyngeal branch of vagus.

Note the nerves in relation with this vessel—(1) The hypo-glossal crosses it near its beginning; (2) the facial crosses it at the upper part; (3) the superior laryngeal with its external laryngeal branch are beneath its lower part; while (4) the glosso-pharyngeal lies beneath its upper part.

It may be ligatured as it lies in the carotid triangle, but its branches are so numerous that its ligature is apt to be followed by secondary hæmorrhage. The best point for the application of the ligature is between the origins of the superior thyroid and lingual arteries. The patient is to be placed in the same position as in ligature of the common carotid and the Surgeon stands on the same side as the vessel to be tied. At this part of its course it is covered by a large plexus of veins, formed by the lingual, facial, and pharyngeal veins, with communications from the superior thyroid and external jugular. The **incision** used in ligature of the internal carotid will also do for ligature of this vessel, or the incision may *be half-an-inch* nearer the middle line of the neck, and should

extend from near the angle of the jaw to the level of the thyroid cartilage. Carefully cut through the structures covering it in the first part of its course. Turn the large veins to one side if possible, or else tie them with a double ligature and cut between. The sterno-mastoid must be pulled backwards, the digastric and stylo-hyoid muscles with the hypo-glossal nerve forwards and upwards, and the parotid gland upwards. The descendens noni is external to and somewhat behind the vessel, and is not likely to be injured, but the thyro-hyoid branch is immediately in front, and if seen should be hooked aside. The vessel is then to be cleared, and the needle passed from the outer side, and in doing so care should be taken to avoid injuring or including the descendens noni nerve, the superior laryngeal nerve, or the ascending pharyngeal artery.

The external carotid may be ligatured for wounds of the main trunk or its branches, various forms of aneurism of the face and scalp, etc. In case of wounds, or aneurism the result of a wound, the vessel or its branches should be secured at the injured point. In cases of idiopathic aneurism and pulsating tumours of scalp, ligature of the common carotid is the more effectual operation, on account of the large number of branches given off by the external.

Collateral Circulation (see Fig. 12).—1. Branches of the external carotid on the side tied anastomosing with the corresponding branches of the opposite side (4), viz.—(*a*) Facial with facial; (*b*) temporal with temporal; (*c*) occipital with occipital; (*d*) superior thyroid with superior thyroid (10). 2. Anastomoses between the subclavian and the external carotid of the side tied—(*a*) Deep cervical (11) from the superior intercostal, with the princeps cervicis (6) of the occipital; (*b*) the vertebral with the occipital in the region of the suboccipital triangle (7); (*c*) inferior thyroid with the superior thyroid (10). 3. Nasal of the ophthalmic anastomosing with the angular of the facial.

THE PULSE IN ANEURISM of the aorta and vessels at the root of the neck.—According to Dr MAHOMED, the chief characters of the aneurismal pulse recognisable by the **finger** are—(1) Delay; (2) diminution in volume; (3) diminution in force; (4) persistency; (5) in some cases a thrill may be felt. In many cases the finger can perceive a want of parallelism in the beats of the radials; but sometimes the differences are too slight to be dectected by the finger.

The characters of a sphygmographic tracing are—(1) A sloping upstroke, due to the delay of the pulse wave; (2) diminished volume of wave; (3) impairment of percussion, from the diminution in the force of the wave; (4) obliteration of secondary waves; (5) inequality of the pressure employed on the two sides; (6) sometimes vibratile waves, corresponding to the thrill sometimes felt by the finger. A constant dissimilarity in the pulse tracings of the two radials is the most valuable sign, and this is best of all demonstrated by sphygmographic tracings; the wave is delayed, it is smaller than the other, and there is loss of tension.

The presence of the signs above enumerated in the pulse at both wrists would point to an aneurism of the ascending arch; if the right pulse be affected more than the left, the aneurism must involve the innominate; if the left more than the right, the aneurism is of the transverse arch beyond the innominate.

CHAPTER VIII.

BRANCHES OF THE EXTERNAL CAROTID.

An Anterior Set.—(1) Superior thyroid; (2) lingual; (3) facial. **A Posterior Set.**—(1) Occipital; (2) posterior auricular; (3) sterno-mastoid (sometimes). **An Ascending Set.**—(1) Temporal; (2) internal maxillary; (3) ascending pharyngeal. The sterno-mastoid branch has three possible modes of origin—(1) From the external carotid; (2) from the occipital; (3) from the superior thyroid.

Thyroid Arteries.—Ligature of these arteries has been practised by some Surgeons as a cure for bronchocele, with but doubtful success. We have already referred to ligature of the **Inferior Thyroid.** (See page 75.)

The Superior Thyroid.—This vessel is a branch of the external carotid. It is the lowest of the three branches arising from the anterior surface of that vessel, and is usually given off not far from its origin, as it lies in the carotid triangle, coming off just below the great cornu of the hyoid bone. The superior thyroid itself, therefore, is at first merely covered by the common investments of the parts, and at this point it may be ligatured. Make an **incision** two inches long parallel with the anterior edge of the sterno-mastoid, but half-an-inch nearer the middle line, so that it shall lie over the external carotid artery, the centre of the incision being opposite the superior cornu of the thyroid cartilage, or the thyro-hyoid space, as the artery usually arises somewhat below the great cornu of the hyoid bone. Here the vessel, passing upwards and inwards, is quite superficial, being covered only by skin, superficial fascia, platysma, and deep fascia, and may be readily tied. There is a well marked venous plexus in front of the vessel, formed by the lingual, superior thyroid, and facial veins, which is the chief difficulty of the operation. After this it takes an arched course downwards, passing beneath the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles to the upper part of the thyroid body.

Branches.—(1) Hyoid branch, runs inwards *below* the hyoid bone. (2) Sterno-mastoid, passes outwards across the carotid sheath to the sterno-mastoid muscle; it is important to note the relation of this little branch to the carotid sheath, as it is in the way in the operation of tying the common carotid above the omo-hyoid. (3) Superior laryngeal, pierces the thyro-hyoid membrane and supplies the mucous membrane of the larynx. (4) Crico-thyroid, runs across the crico-thyroid membrane. This little branch should be remembered in the operation of laryngotomy, although, from its small size, it seldom gives rise to any trouble. Occasionally, however, it is of large size; I have seen it as large as an ordinary radial. (5) Terminal branches to the thyroid body.

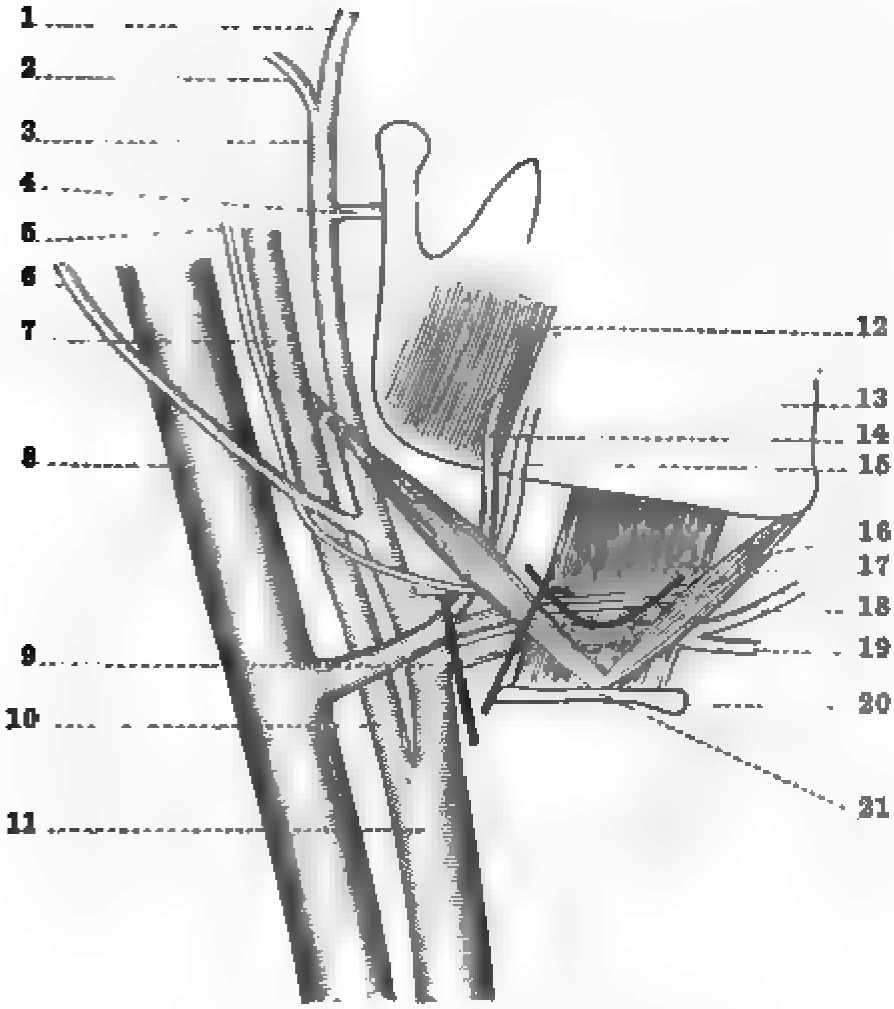
THE LINGUAL ARTERY.

It may be necessary to ligature this vessel to restrain profuse hæmorrhage from the tongue, *e.g.*, in cancerous ulcers, or for the purpose of starving such growths, or preliminary to excision of the tongue, and in macroglossia. **Origin.**—From the anterior border of the external carotid, either just above or immediately below the level of the great cornu of the hyoid bone. **Extent.**—From its origin to the anterior border of the hyo-glossus muscle. **Course.**—At first inwards above the hyoid bone, and then upwards and inwards beneath the hyo-glossus.

Relations.—In the **first part** of its course—from its origin to the posterior border of the hyo-glossus—it passes obliquely upwards and inwards to the great cornu of the hyoid bone, and is quite superficial, being simply *covered* by the skin, fascia, and platysma, and *rests on* the middle constrictor of the pharynx. In the **second part** of its course, that beneath the hyo-glossus, it runs forwards parallel with the great cornu of the hyoid bone for a little way, and then ascends to the under surface of the tongue. Here it is *covered* by the skin, fascia, and platysma, crossed by the posterior belly of the digastric and the stylo-hyoid muscles, and sometimes also by the ninth nerve near the posterior border of the hyo-glossus, and lastly, it is covered by the hyo-glossus muscle itself. In its second part it *rests on* the middle constrictor and the genio-hyo-glossus muscle. Properly speaking the vessel ends, as such, at the anterior border of the hyo-glossus, and its continuation, the ranine

Fig. 17.

LINGUAL ARTERY.



1. Anterior Temporal.
2. Posterior Temporal.
3. Temporal.
4. Internal Maxillary.
5. Hypoglossal Nerve.
6. Occipital Artery.
7. Internal Carotid.
8. Internal Jugular Vein.
9. Annandale's Incision.
10. Internal Carotid.
11. Common Carotid.
12. Masseter.
13. Jaw.
14. Facial Vein.
15. Facial Artery.
16. Digastric.
17. Hyo-Glossus.
18. Sublingual.
19. Ranine.
20. Hyoid Bone.
21. Central Tendon of Digastric.

The dark lines indicate different forms of Incision for Ligature of the Lingual.

artery, runs forwards to the tip of the tongue to end at the side of the frænum linguæ. In ligaturing this vessel, the **patient's** shoulders should be slightly raised, the head thrown well back over a small pillow, and the face turned towards the opposite shoulder. The most trustworthy **superficial guide** to the vessel is the great cornu of the hyoid bone. The **Surgeon** stands on the same side as the vessel tied, above the chin on the right side, but below it on the left (Fig. 17).

Incisions.—To tie it in the first part of its course an **incision** is made horizontal or slightly convex downwards, about two inches in length, on a level with the greater cornu of the hyoid bone, and extending from the body of that bone to the anterior border of the sterno-mastoid, its centre corresponding to the end of the greater cornu. This incision secures the vessel near its origin. Mr ANNANDALE uses a vertical incision, following the course of the external carotid artery, and half-an-inch anterior to that vessel. An oblique incision, passing downwards and backwards over the greater cornu, may also be used; thus we may use one of three forms—horizontal, oblique, and transverse,—but in all cases the centre of the incision must correspond to the end of the greater cornu. Cut through the superficial structures already mentioned, and look for the **deep guide**, the ninth nerve, which is usually accompanied by a branch of the lingual vein. The artery is deeper than the nerve as it has to pass under the hyo-glossus, while the nerve passes over that muscle. The ninth nerve, with the posterior belly of the digastric and stylo-hyoid muscles, must be displaced upwards, and the external carotid artery backwards, by means of blunt hooks, and then, with the great cornu of the hyoid bone in view, search for the vessel in the loose cellular tissue. At first sight it might seem an easy operation to secure the vessel at this part of its course where it is so superficial, but this is by no means the case. There are **three reasons** for this—(1) Because behind the vessel is the soft mobile wall of the pharynx, and, for this reason, it is impossible to get the artery fixed, and in clearing the vessel great care is necessary lest the wall of the pharynx be wounded. (2) Over the vessel in this region is a large plexus of veins, formed chiefly by the lingual and facial (on their way to empty into the internal jugular), with communications from the

superior thyroid and external jugular veins. (3) Although apparently so superficial, yet, in the actual operation, the vessel lies at the bottom of a deep narrow pit, with the mobile pharyngeal wall forming its floor. Another objection to this operation is that the vessel is often joined at its origin with the facial or superior thyroid. For these reasons the next form of incision is the one usually adopted, except in cases where the operation is performed preliminary to excision of the tongue, when it is necessary to tie the vessel in its first part, and as close to the parent trunk as possible, in order to be sure that, in removing the tongue, the artery will not be cut between the parent trunk and the ligatured point.

To tie it in the **second part** of its course, *i.e.*, as the vessel lies beneath the hyo-glossus at the apex of the digastric triangle, a curved **incision** is made from a point a little below and behind the symphysis menti down to the level of the hyoid bone, and then turning upwards till it nearly reaches the angle of the jaw. It must not be carried quite up to the angle of the jaw lest the facial vein be injured. The facial artery is safe, as it is in the substance of the sub-maxillary gland, whereas the vein is on its surface. After dividing the superficial structures and deep fascia, the sub-maxillary gland is exposed, and must be displaced upwards with a blunt hook. Then the boundaries of the triangle in which the vessel lies are to be recognised, viz., the two bellies and the intervening tendon of the digastric on each side, and the ninth nerve above the nerve is to be dissected up a little and held aside, when the hyo-glossus muscle will be exposed. The fibres of this muscle are then to be divided transversely about a couple of lines above the hyoid bone, the vessel carefully cleaned, and the needle passed from above downwards. In the dead body the muscle seems thinner than one might expect, and, unless care be taken, the operator may easily open into the pharynx. In this operation the trouble with veins is not so great as in the first form. Some operators use an incision an inch and a quarter in length, parallel with, and one-third of an inch above, the great cornu of the hyoid bone.

PECULIARITIES.—The lingual artery sometimes arises from a trunk common to it and the facial; less frequently it is joined with the superior thyroid.

Branches.—(1) Hyoid, which runs along the upper border of the hyoid bone. (2) Dorsalis linguæ, which arises and ascends beneath the hyo-glossus to the dorsum of tongue. In the second method of ligature, the *dorsalis linguæ* is usually given off between the ligature and the parent trunk; and ligature in this situation, therefore, will not stop hæmorrhage from the base of the tongue. (3) Sub-lingual branches to sub-lingual gland. (4) Ranine, the direct continuation of the lingual, which runs forward to the tip of the tongue, and ends in the frænum linguæ. To avoid this little vessel, in relieving the condition known as "**tongue-tie,**" the prominent tight *edge* only of the frænum is nicked with scissors, and as close to the jaw as possible, any further freeing must be done with the thumb or finger nail. The ranine vein is more superficial than the artery; division, or, more probably, *partial* division, of these vessels has led to fatal hæmorrhage in children, no doubt helped by efforts at sucking.

RÉSUMÉ of second form of operation:—

1. Make a curved incision with the convexity downwards.
2. Take care of facial vein at the outer end of the incision.
3. Open the deep fascia and hook up the sub-maxillary gland.
4. Expose the central tendon of the digastric muscle, and then—
5. Expose the ninth nerve, which will be seen higher up passing beneath the mylo-hyoid but superficial to the hyo-glossus, and often accompanied by a lingual vein, which must not be mistaken for the artery.
6. Divide the fibres of the hyo-glossus on a director from the outer edge, and then clear and tie the artery, passing the needle from above downwards.

FACIAL ARTERY.

The first of the incisions for ligature of the lingual would also expose the origin of the facial. It arises from the external carotid artery, a little above the lingual, lying at first in the carotid triangle, where it is simply covered by the superficial investments of the parts (skin, platysma, and fasciæ). It is then crossed by the

posterior belly of the digastric and stylo-hyoid muscles and ninth nerve. After this it passes through a groove in the posterior and upper border of the sub-maxillary gland, where it makes a sigmoid flexure, crosses the lower jaw, lying on the bone, in a little hollow just about the point where the body joins the ramus, and immediately in front of the masseter muscle, and only covered by the skin, fascia, and platysma. Here its pulsations can be felt during life, and it may be readily compressed with the finger, or ligatured by an **incision** one inch in length parallel with the fibres of the masseter. The Surgeon stands on the same side as the vessel to be tied. At its origin in the neck it may be tied through an incision, similar to that used by Mr ANNANDALE for the lingual, only a little higher up; displace the posterior belly of the digastric with the stylo-hyoid, and the sub-maxillary gland upwards and forwards, carefully work through the venous plexus, isolate and tie the vessel. After this, its general direction is towards the angle of the mouth, the angle of the nose, and the inner angle of the eye, but in a very tortuous manner. In its course through the face it is covered by the superficial structures and platysma, and that special part of the platysma known as the risorius muscle: it is also covered by the zygomatic muscles, and crossed by branches of the facial nerve. It rests on—(1) The lower jaw; (2) buccinator; (3) levator anguli oris; (4) levator labii superioris. The facial vein lies posterior to the artery on the face, and is more superficial in the neck, as the artery passes through the substance of the sub-maxillary gland, whereas the vein passes over its surface. It is further less flaccid than most superficial veins, and remains patent after it is cut across.

PECULIARITIES.—The facial artery may arise by a common trunk with the lingual. Sometimes it terminates as the sub-mental, and in other cases may only supply the face as high as the angle of the mouth or nose.

BRANCHES.—In neck.—(1) Inferior or ascending palatine, which passes upwards between the stylo-glossus, and the stylo-pharyngeus muscles supplying them, the tonsil, and the Eustachian tube, and sends a branch through the space of Morgagni to the soft palate. (2) Tonsillar, which perforate the superior constrictor to reach the tonsils. (3) Glandular to sub-maxillary gland. (4) Sub-mental, given off immediately below the lower jaw to the chin.

This is the largest branch, and must be kept in mind in operations about the lower jaw, such as excision, etc.; it runs forwards on the mylo-hyoid muscle. **On the face.**—(1) Inferior labial, which passes beneath the depressor anguli oris to supply the lower lip and chin. (2) The two coronary arteries which pass along the free margin of each lip. They pass beneath the depressor anguli oris, and then perforate the orbicularis oris to run in a tortuous course between this muscle and the mucous membrane. When the lip is struck against the teeth, the coronary artery may be divided and bleed into the mouth without any sign of external wound, more especially in the case of drunk persons. The blood then trickles down the throat and is swallowed, and some time after may be vomited up, giving rise to a suspicion of internal injury; in all such cases, therefore, always examine the inside of the lips. The superior is the larger, and gives off the artery to the septum of the nose. In operations about the lips, such as the removal of an epithelioma, these branches must be kept in mind; in this operation, performed on the lower lip by the V-shaped incision, the inferior coronary and the inferior labial are both divided. (3) Lateral nasal to side of nose. (4) Angular, its terminal branch, anastomosing at the inner angle of the orbit with the nasal branch of the ophthalmic; and this is one reason why leeches at the inner angle of the eye relieve congestion of the eye or brain. It also anastomoses with the infra-orbital branch of the internal maxillary in the same region.

OCCIPITAL ARTERY.

This vessel arises from the posterior surface of the external carotid, just as that vessel is about to pass beneath the posterior belly of the digastric. It may be divided into three parts—(1) A part that passes upwards and backwards, almost parallel with and partially overlapped by the posterior belly of the digastric and stylo-hyoid, to a point between the transverse process of the atlas and mastoid process of the temporal bone. This part is usually quite superficial at first, being simply covered by the integument; afterwards it is overlapped by the muscles already mentioned, and by part of the parotid gland. It, however, *crosses* the following important structures—(*a*) Internal carotid artery; (*b*) vagus; (*c*) internal jugular vein; (*d*) spinal accessory nerve; (*e*) ninth nerve

(hypo-glossal) which hooks round it; (*f*) gangliated cord of the sympathetic. (2) A part passing backwards and inwards just below the superior curved line. At this part of its course it *lies* on—(*a*) Rectus lateralis; (*b*) superior oblique; and (*c*) complexus; and is *covered* by—(*a*) trapezius; (*b*) sterno-cleido-mastoid; (*c*) splenius capitis; (*d*) digastric; (*e*) trachelo-mastoid; and is overlapped by (*f*) the mastoid process. Under the mastoid process it lies in the "occipital groove." (3) The third part pierces the trapezius and turns upwards to the scalp: this part is accompanied by the great occipital nerve and a cutaneous twig from the sub-occipital as well.

In the **first part** of its course it may be tied through an **incision** along the anterior border of the sterno-mastoid, with its centre opposite the angle formed by this muscle, and the posterior belly of the digastric and stylo-hyoid. In the **second part** of its course it may be reached by an **incision** an inch and a half long, a little behind and below the mastoid process, passing obliquely upwards and backwards. To reach the vessel in this region, we divide skin and fascia, aponeurosis of the sterno-mastoid, the splenius capitis, and part of the trachelo-mastoid. At this part of its course, the vessel lies a little above the superior oblique muscle.

PECULIARITIES.—The occipital artery is sometimes derived from the internal carotid, or from the ascending cervical branch of the inferior thyroid.

BRANCHES.—(1) A sterno-mastoid branch; (2) auricular, to concha; (3) meningeal, which enters the skull through the jugular foramen; (4) princeps cervicis. The princeps cervicis passes downwards and divides into a superficial and deep part. The *superficial* part runs beneath the splenius, lying on the complexus: the *deep* branch lies between the complexus and the semi-spinalis colli, and anastomoses with the vertebral, and the profunda cervicis branch of the superior intercostal artery, in the region of the sub-occipital triangle. This anastomosis forms an important collateral supply in the ligature of the common carotid or subclavian artery. (5) Occipital to scalp, which anastomose with the corresponding branches from the opposite side, and with the temporal arteries.

Posterior Auricular.—This branch is given off above the digastric and stylo-hyoid muscles, runs along the upper border of the digastric, and passes between the facial and spinal accessory nerves. Its

course must be remembered in making the incision through the integuments when about to trephine the mastoid cells, as it lies in the interval between the mastoid process and the external auditory meatus. It anastomoses with the occipital and temporal arteries. Its **branches** are—(1) The *stylo-mastoid*, which enters the stylo-mastoid foramen and supplies the middle ear, mastoid cells, and semi-circular canals; (2) the *auricular*, which is distributed to the back of the cartilage of the ear.

Ascending Pharyngeal.—This branch arises near the commencement of the external carotid, and ascends by the side of the pharynx, and to the inner side of the internal carotid, to the base of the skull, beneath the other branches of the external carotid, and also beneath the stylo-pharyngeus muscle, but lying on the rectus capitis anticus major. Its **branches** are distributed to the muscles in this region, to the dura mater, and to the pharynx. The branches to the dura mater (*meningeal*) pass through the foramen lacerum medius, foramen lacerum posticus, and sometimes through the anterior condyloid foramen. The *pharyngeal* branches pass through the space of Morgagni to supply the soft palate and tonsil, and anastomose with the ascending palatine of the facial. This vessel lies close to the tonsil, and a case is recorded by Mr Baker where a wound of the artery from the throat, by the stem of a tobacco-pipe, proved fatal by repeated hæmorrhages, notwithstanding ligature of the common carotid. At the post-mortem it was discovered the pipe stem had completely divided the artery.

Temporal Artery.—This is one of the terminal branches of the external carotid. It arises in the parotid gland on a level with the neck of the condyle of the lower jaw, and passes upwards over the root of the zygoma, in front of the ear, to the scalp, and divides, about two inches above the zygoma into anterior and posterior branches, which pass in directions indicated by their names. As it crosses the root of zygoma it is covered (1) by a dense fascia derived from the parotid gland; (2) several veins; it is also accompanied in this region by branches of the facial and the auriculo-temporal nerves. It is on account of these relations that the operation of arteriotomy should not be performed in this situation, as the dense fascia interferes with the free flow of blood during the operation, as well as causing some difficulty in controlling the

hæmorrhage afterwards. Further, one of the veins might be wounded in the operation, and subsequently give rise to varicose aneurism or aneurismal varix; or severe neuralgia might result from injury to the auriculo-temporal nerve. For the purpose of arteriotomy the anterior temporal is the branch usually selected. The vessel may be **tied by a vertical incision** an inch and a half in length, midway between the condyle of the jaw and the external auditory meatus. The vein lies behind it, and the auriculo-temporal nerve lies in close relation to it; both vein and nerve must be carefully avoided in this operation.

Branches—(1) *Anterior temporal;* (2) *posterior temporal;* (3) *transverse facial*, given off in the substance of the parotid gland, and runs forwards over the masseter muscle, just below the zygoma but above Stenson's duct, and anastomoses with the infra-orbital and facial. (4) *Middle temporal*, which pierces the temporal fascia and supplies the temporal muscle. This vessel sometimes gives off an *orbital* branch, which runs along the upper border of the zygoma between the two layers of the temporal fascia, to the outer angle of the orbit. (5) *Anterior auricular*, to the anterior part of pinna, the lobule, and part of the external auditory meatus.

THE INTERNAL MAXILLARY ARTERY.

This vessel has, so far as I am aware, but little direct surgical interest. Its branches, however, are involved in many important surgical operations, such as excision of the upper and lower jaws, hæmorrhage after the removal of teeth, etc.; and its middle meningeal branch may be injured in fracture of the temporal region of the skull. **The middle meningeal** enters the skull through the foramen spinosum of the sphenoid bone, and divides into two branches, an anterior and a posterior; it is the **anterior** branch that possesses the greatest interest, from a surgical point of view. From the foramen spinosum it crosses the great wing of the sphenoid, and then enters a canal or groove in the anterior inferior angle of the parietal bone. At this part of its course its position may be indicated on the surface by taking a point an inch and a quarter behind the external angular process of the frontal bone, and an inch and a half above the zygoma. After this the anterior branch passes upwards and slightly backwards to the upper margin of the parietal bone,

artery, runs forwards to the tip of the tongue to end at the side of the frænum linguæ. In ligaturing this vessel, the **patient's** shoulders should be slightly raised, the head thrown well back over a small pillow, and the face turned towards the opposite shoulder. The most trustworthy **superficial guide** to the vessel is the great cornu of the hyoid bone. The **Surgeon** stands on the same side as the vessel tied, above the chin on the right side, but below it on the left (Fig. 17).

Incisions.—To tie it in the **first part** of its course an **incision** is made horizontal or slightly convex downwards, about two inches in length, on a level with the greater cornu of the hyoid bone, and extending from the body of that bone to the anterior border of the sterno-mastoid, its centre corresponding to the end of the greater cornu. This incision secures the vessel near its origin. Mr ANNANDALE uses a vertical incision, following the course of the external carotid artery, and half-an-inch anterior to that vessel. An oblique incision, passing downwards and backwards over the greater cornu, may also be used; thus we may use one of three forms—horizontal, oblique, and transverse,—but in all cases the centre of the incision must correspond to the end of the greater cornu. Cut through the superficial structures already mentioned, and look for the **deep guide**, the ninth nerve, which is usually accompanied by a branch of the lingual vein. The artery is deeper than the nerve as it has to pass under the hyo-glossus, while the nerve passes over that muscle. The ninth nerve, with the posterior belly of the digastric and stylo-hyoid muscles, must be displaced upwards, and the external carotid artery backwards, by means of blunt hooks, and then, with the great cornu of the hyoid bone in view, search for the vessel in the loose cellular tissue. At first sight it might seem an easy operation to secure the vessel at this part of its course where it is so superficial, but this is by no means the case. There are **three reasons** for this—(1) Because behind the vessel is the soft mobile wall of the pharynx, and, for this reason, it is impossible to get the artery fixed, and in clearing the vessel great care is necessary lest the wall of the pharynx be wounded. (2) Over the vessel in this region is a large plexus of veins, formed chiefly by the lingual and facial (on their way to empty into the internal jugular), with communications from the

superior thyroid and external jugular veins. (3) Although apparently so superficial, yet, in the actual operation, the vessel lies at the bottom of a deep narrow pit, with the mobile pharyngeal wall forming its floor. Another objection to this operation is that the vessel is often joined at its origin with the facial or superior thyroid. For these reasons the next form of incision is the one usually adopted, except in cases where the operation is performed preliminary to excision of the tongue, when it is necessary to tie the vessel in its first part, and as close to the parent trunk as possible, in order to be sure that, in removing the tongue, the artery will not be cut between the parent trunk and the ligatured point.

To tie it in the **second part** of its course, *i.e.*, as the vessel lies beneath the hyo-glossus at the apex of the digastric triangle, a curved **incision** is made from a point a little below and behind the symphysis menti down to the level of the hyoid bone, and then turning upwards till it nearly reaches the angle of the jaw. It must not be carried quite up to the angle of the jaw lest the facial vein be injured. The facial artery is safe, as it is in the substance of the sub-maxillary gland, whereas the vein is on its surface. After dividing the superficial structures and deep fascia, the sub-maxillary gland is exposed, and must be displaced upwards with a blunt hook. Then the boundaries of the triangle in which the vessel lies are to be recognised, viz., the two bellies and the intervening tendon of the digastric on each side, and the ninth nerve above the nerve is to be dissected up a little and held aside, when the hyo-glossus muscle will be exposed. The fibres of this muscle are then to be divided transversely about a couple of lines above the hyoid bone, the vessel carefully cleaned, and the needle passed from above downwards. In the dead body the muscle seems thinner than one might expect, and, unless care be taken, the operator may easily open into the pharynx. In this operation the trouble with veins is not so great as in the first form. Some operators use an incision an inch and a quarter in length, parallel with, and one-third of an inch above, the great cornu of the hyoid bone.

PECULIARITIES.—The lingual artery sometimes arises from a trunk common to it and the facial; less frequently it is joined with the superior thyroid.

We **cut through**—(1) Skin; (2) superficial fascia; (3) platysma; (4) deep fascia; (5) clavicular head of the pectoralis major, which must be divided across its fibres, taking care to avoid the *cephalic vein*, which is seen at the outer angle of the incision, in the groove between it and the deltoid. After this we meet with a quantity of fatty tissue, in which ramify the structures that pierce the costo-coracoid membrane, viz.—(*a*) The cephalic vein; (*b*) external anterior thoracic nerve; (*c*) thoracic axis, or acromio-thoracic artery; (*d*) superior thoracic artery; and (*e*) corresponding veins. The arm having been brought to the side, and the upper edge of the pectoralis minor muscle exposed and displaced downwards by a broad copper spatula, and any large arterial branch pulled inwards by a blunt hook, pass carefully through the fatty tissue, cutting as little as possible, lest the above structures be injured, till the axillary sheath is exposed. (6) Displace the vein inwards, and then open the sheath, taking special care not to wound the vein, which is *superficial* and internal to, and also overlaps, the artery. The cords formed by the union of the spinal nerves entering into the formation of the brachial plexus, lie to its outer side, or may partially overlap it. Clear the artery with a director, and pass the needle *from* the vein, and above the origin of the thoracic axis. At this part of the axilla, the artery, vein, and nerves, all lie obliquely to each other—the vein overlapping the artery, and the artery overlapping the nerves. This is the position of the various structures when the arm is hanging by the side; but when it is abducted to any extent, the vein is almost right in front of the artery. Take care not to include the anterior thoracic nerve.

Behind this part of the vessel is the first digitation of the serratus magnus and the posterior thoracic nerve (Nerve of Bell). Ligature of this part of the axillary artery is a dangerous operation, because of—(1) Its great depth; (2) its relation to other blood vessels, *e.g.*, the axillary and cephalic veins, and branches of the thoracic axis; (3) its relation to nerves, *e.g.*, the external anterior thoracic in front, and the posterior thoracic behind—for these reasons, it is much better to tie the third part of the subclavian.

RÉSUMÉ of the chief steps of the foregoing operation:—

1. Make the curved incision, taking care of the cephalic vein at the outer angle of incision.

2. Expose the pectoralis major, separate the clavicular from the sternal head, beginning at the inner end of the wound, and then divide it on a director, or else use the finger and a probe-pointed bistoury. Bring the arm to the side, and
3. After this expose the upper edge of the pectoralis minor, with the finger and handle of the knife, taking care not to wound the acromio-thoracic vessels.
4. Use the branches of the acromio-thoracic artery, or the cephalic vein, as the guide to the position of the axillary.
5. Clear the vessel as near the clavicle as possible, and well above the origin of the thoracic axis.
6. Pass the needle from the inner side.

Collateral Circulation (Fig. 18).—If tied **above** the thoracic axis it is the same as in ligature of the third part of the subclavian. If tied **below** the axis, in addition to the chief collateral branches mentioned under "Collateral Circulation" (see page 72) in ligature of the subclavian, we have—1. Branches from the thoracic axis (4), and superior thoracic (8), anastomosing with branches from the two circumflex arteries (9) from third part of the axillary. 2. The long thoracic (15), anastomosing with the aortic intercostals (18) and internal mammary (11).

THE SECOND PART.—Relations.—In *front*—The pectoralis major and pectoralis minor, with skin, fascia, etc. *Behind*—The subscapularis and the posterior cord of the brachial plexus. *Inner side*—The vein and the inner cord. *Outer side*—The outer cord of the plexus. The part beneath the pectoralis minor is not tied except when wounded—(1) Because it is so short and gives off two or three branches; (2) it is too deeply placed; (3) it is so closely surrounded by nerve trunks. In ligaturing the first two parts of this vessel for a wound of the main trunk or its branches, it is customary to make the incision in the line of the artery, across the fibres of the pectorals.

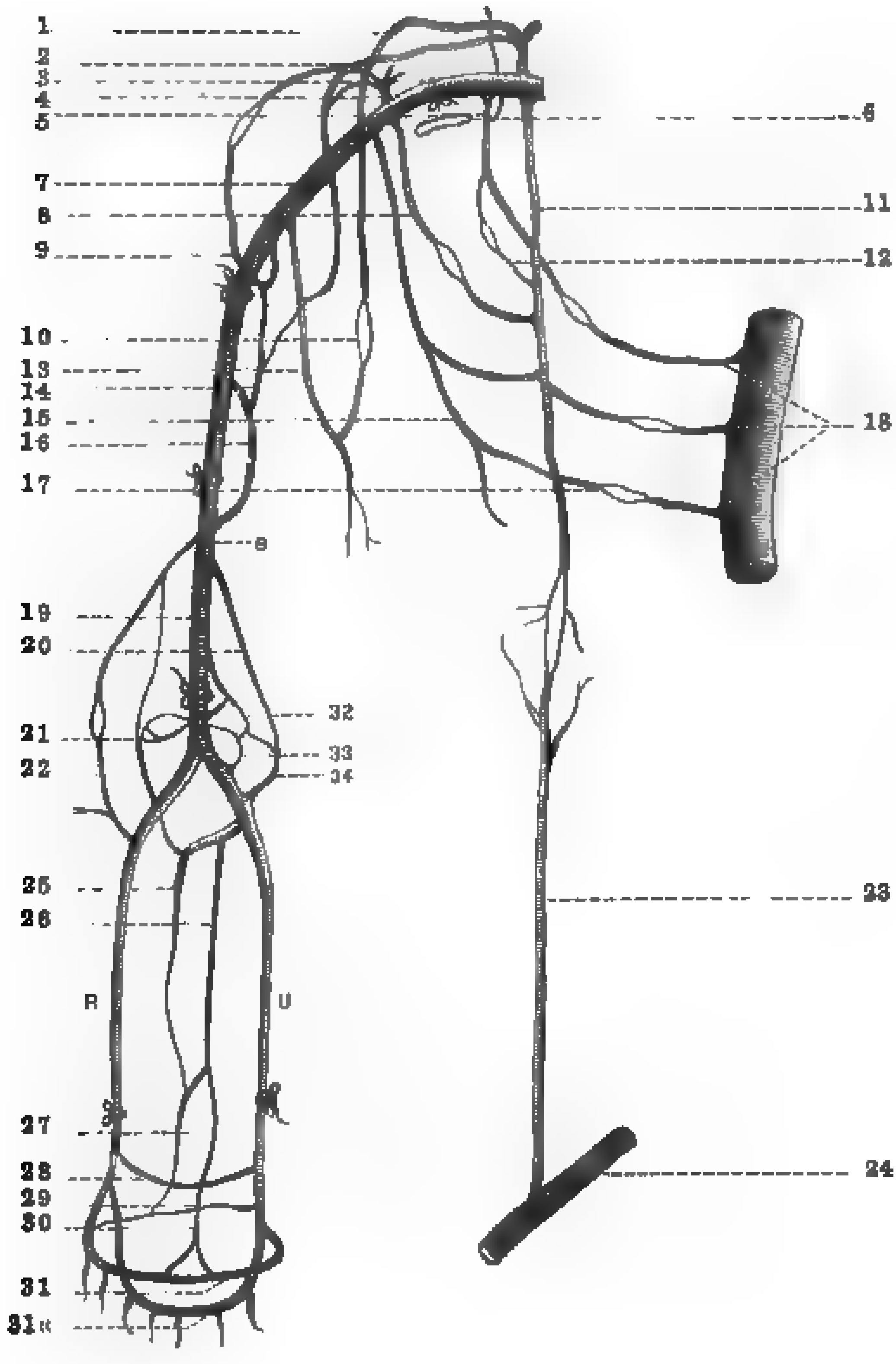
THE THIRD PART.—This is the longest of the three parts, and extends from the lower border of the pectoralis minor to the lower border of the teres major: it is twice as long as either of the others.

Position of the Arm.—The arm is abducted to a right angle with

Fig. 18.

Collateral Circulation of the Upper Extremity.

(After Smith and Walsham.)



Explanation of Fig. 18.

1. Posterior scapular artery.
2. Supra-scapular artery.
3. Subclavian artery.
4. Thoracic axis.
5. Superior intercostal artery.
6. The first rib.
7. Axillary artery.
8. Superior thoracic branch.
9. Posterior circumflex artery, anastomosing with the thoracic axis.
10. Anastomosis between the posterior scapular and the dorsalis scapulæ.
11. The internal mammary.
12. Anastomosis between the internal mammary and the superior intercostal.
13. Subscapular artery.
14. Anastomosis between the superior profunda and the posterior circumflex.
15. Long thoracic.
16. The superior profunda.
17. Anastomosis between the long thoracic, internal mammary, and aortic intercostals.
18. Aortic intercostals.
19. Brachial artery (B).
20. Inferior profunda.
21. Interosseous recurrent.
22. Radial recurrent.
23. Deep epigastric.
24. External iliac.
25. The posterior interosseous.
26. Anterior interosseous.
27. Terminal branches of the anterior interosseous.
28. Anterior carpal arch.
29. Posterior carpal arch.
30. Recurrent branches.
31. Deep palmar arch.

31*a*. Superficial palmar arch.

32. Anastomotic branch.
33. Anterior ulnar recurrent.
34. Posterior ulnar recurrent.

B. Brachial artery. R. Radial artery. U. Ulnar artery.

the trunk and rotated outwards by an assistant, and the fore-arm at the same time fully supinated; the **operator** stands between the arm and the trunk on both sides of the body.

Superficial Guide.—The inner edge of the prominence caused by the coraco-brachialis, or else we may divide the base of the axilla into thirds, when the artery will be found to lie at the junction of the anterior with the middle third. Make an **incision** along the inner side of this muscle and parallel with the anterior fold of the axilla, for about three inches, into the hollow of the armpit. **Cut through**—(1) Skin; (2) fascia, avoiding the basilic vein should it be in the way, and expose the edge of the coraco-brachialis. After dividing the superficial and deep fascia, the median and the internal cutaneous nerves will be seen, with the artery behind and between them, or more correctly, the artery is really surrounded by nerve trunks:—To the *outer side* are the median and the musculo-cutaneous nerves; on the *inner side*, the ulnar and nerve of Wrisberg; in *front*, the internal cutaneous; *behind*, the musculo-spiral and circumflex. The axillary vein lies to its inner side, and partially overlaps it. These nerve trunks form the **Deep Guide**, and in the midst of them the artery will usually be found. Relax the parts by bending the fore-arm, and then, by means of blunt hooks, displace the median nerve to the outer side, the axillary vein with the ulnar and internal cutaneous nerves, and the basilic vein, if present, to the inner side. Carefully expose and open the sheath near the lower part of the artery, separate the vessel from the sheath, and pass the needle from the inner side, taking care not to include the musculo-spiral or circumflex nerves which lie behind the vessel. To give, shortly, the entire **Relations** of this part of the artery.—In *front*—(1) Integument and fascia, and this only at the lower part of its course; (2) pectoralis major (at the upper part), and internal cutaneous nerve; (3) inner head of median. *Behind*—(1) Subscapularis; (2) tendons of latissimus dorsi and teres major; (3) musculo-spiral and circumflex nerves. On the *outer side*—(1) Coraco-brachialis; (2) median nerve; (3) musculo-cutaneous nerve. On the *inner side*—(1) Ulnar nerve; (2) nerve of Wrisberg; (3) axillary vein. The median nerve has a triple relation to this part of the artery—(1) Its two heads embrace it; (2) it usually lies above it; (3) it is placed to its outer side. This part of the axillary

artery is better fitted for ligature than the parts we have previously considered—(1) It is twice as long as either of the others; (2) its lower part (half or third) is simply covered by the common tegumentary structures, and has no muscle in front of it; (3) its branches come off well up towards its beginning, and are therefore out of the way at the point where the artery is usually ligatured. This is important, because, if the vessel be ligatured too near these branches, secondary hæmorrhage is apt to occur. Therefore, the ligature should be applied as low down as possible.

PECULIARITIES.—(1) The artery may be covered by a muscular slip from the latissimus dorsi; (2) in one out of every ten cases there are two arteries instead of one, the second usually being one of the arteries of the fore-arm, usually the radial, sometimes the ulnar, and still more rarely, the interosseous. In other cases, the circumflex, subscapular, and profunda arteries arise from the third part by a common trunk; (3) the position of the nerves vary—instead of encircling the axillary artery, they may encircle a large branch formed by the union of several of the usual branches, and, in this case, they would therefore be useless as the "deep guide."

RÉSUMÉ of the chief points in ligature of third part of axillary:—

1. Make an incision, three inches long, at the junction of the anterior and middle thirds of the axilla, from the prominence of the coraco-brachialis to the centre of the hollow of the axilla.
2. At first the incision must go through skin and superficial fascia only, and, if necessary, avoid the basilic vein at the outer end of the incision.
3. Then open the deep fascia forming the base of the axilla, when probably the axillary vein and the median nerve will present; then flex the fore-arm, and—
4. Hold the lips of the wound aside and displace the vein with the internal cutaneous nerve to the inner side, and the median nerve with the coraco-brachialis muscle to the outer side.
5. Clear the artery near its termination and ligature, passing the needle from the inner side.

Collateral Circulation (see Fig. 18).—If tied above the subscapular branch, it is the same as when the first part is ligatured. If tied below this branch, the collateral anastomoses are small, but usually sufficient—1. Anastomoses between branches of the posterior circumflex (9) and the superior profunda (16). 2. Anastomoses between branches of the subscapular (13) and the superior profunda (16). 3. Anastomoses through the coraco-brachialis, biceps, and the long head of the triceps—muscular branches. 4. Through the shaft of the humerus.

An **Axillary Aneurism** presents as a pulsating tumour immediately below the clavicle, under the great pectoral or at the anterior fold of the axilla. There is pain and numbness in the arm and hand from pressure on the brachial plexus, and œdema from pressure on the axillary vein; the symptoms have been often mistaken for rheumatism of the arm and shoulder, and rubbing and other remedies recommended, without a proper examination. At first it presses principally on the nerves of the axilla, but as it enlarges it tends to curve forwards, bulging the anterior wall before it. In ligature, special care must be taken not to wound the axillary vein itself, nor any of its feeders close to their junction with it, as air is apt to be sucked in by the aspirating power of the thorax, and also because the fascia in this region is adherent to the vein and prevents its collapse; and for a like reason it bleeds very severely when wounded. The **Axillary Vein** is formed by the union of the basilic with the venæ comites of the brachial, usually at the lower border of the subscapularis muscle. Aneurism in this region is common on account of the movements of the limb, and its liability to share the effects of injuries, such as sudden wrenches and contusions.

BRANCHES.—Of the First Part—(1) The superior thoracic; (2) acromio-thoracic, or thoracic axis, situated at the *upper* border of the pectoralis minor. **From the Second Part**—(1) The long thoracic or external mammary, which runs along in the *anterior fold* of the axilla at the *lower* border of the pectoralis minor to the mammary region; and (2) alar thoracic. **From the Third Part**—(1) The subscapular artery, which runs along in the *posterior fold* of the axilla at the lower border of the subscapularis muscle; (2) posterior circumflex; and (3) anterior circumflex. These two

encircle the surgical neck of the humerus, and must be carefully kept in mind in excision of the shoulder joint. The **circumflex nerve** accompanies the posterior vessel, and its position should be kept in mind in cases of supposed contusion leading to paralysis of the deltoid. As a guide to the other branches of the axillary remember the position of the pectoralis minor: its *upper border* indicated by a line from the upper border of the third rib to the coracoid process; its *lower border* by a line from the lower border of the fifth rib to the coracoid process.

BRACHIAL ARTERY.

Origin.—It is the direct continuation of the axillary. **Extent.**—From the lower border of the teres major to a point opposite the neck of the radius—about half-an-inch below the bend of the elbow—where it divides into radial and ulnar arteries. **Course.**—Its course corresponds to a depression along the inner border, first of the coraco-brachialis and then of the biceps muscle, or a line drawn from the junction of the anterior with the middle third of the base of the axilla to the middle of the bend of the elbow. It is at first to the inner side of the humerus, but gradually turns to the front of that bone; in applying digital compression this relation of the artery to the humerus must be kept in mind, *e.g.*, if it is compressed at the upper part the pressure must be directed from within outwards, if at the lower part from before backwards (Fig. 19).

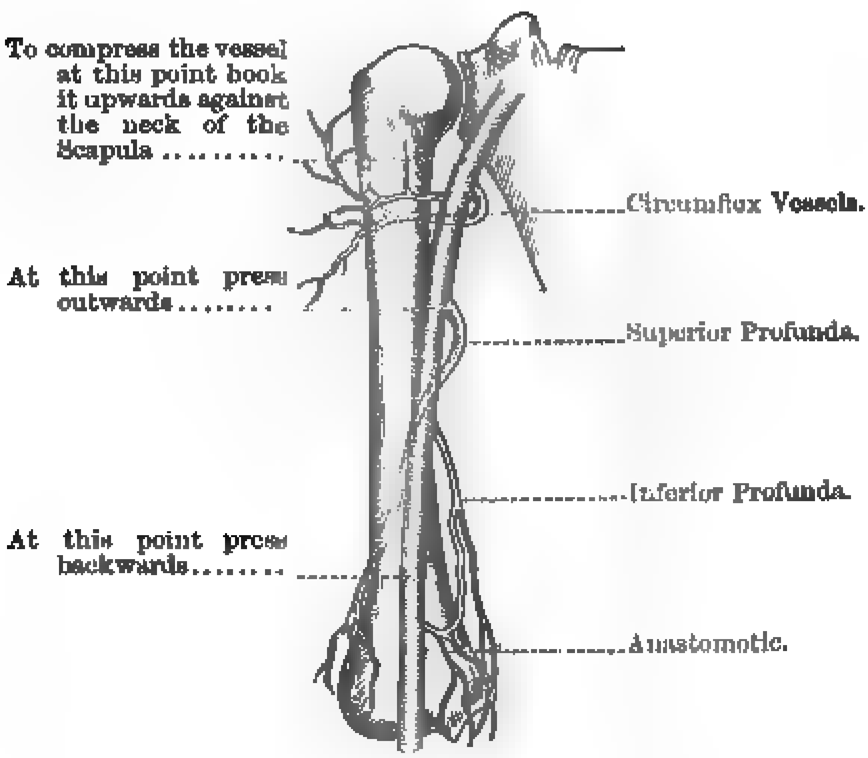
Relations of the Vessel.—In *front*—(1) The skin, superficial and deep fascia; (2) bicipital fascia, with median basilic vein lying on it; and (3) median nerve crossing from the outer to the inner side, and occasionally the internal cutaneous at its upper part. Note the triple relation of this nerve to the artery—at the *outer* side, above; in *front*, about the middle; and at its *inner* side, below. *Behind*—(1) The long and inner heads of triceps; (2) insertion of coraco-brachialis; (3) brachialis anticus; and (4) musculo-spiral nerve, with superior profunda artery, lying between it and the long head of triceps. On the *inner* side—(1) The median, ulnar, and internal cutaneous nerves; and (2) basilic vein. On the *outer* side—(1) The median nerve; (2) coraco-brachialis; and (3) biceps.

The vessel may be ligatured—(1) In the **upper third** of its course, above the origin of the superior profunda. Here the coraco-

brachialis is the **guide**; the median nerve is to its outer side, and the ulnar and internal cutaneous to its inner side. The steps of the operation are precisely similar to ligature of the third part of the axillary, low down. (2) In its **middle third**, below the origin of both the profunda arteries, the point usually selected; the edge of the biceps is the **guide** to the vessel and the median nerve crosses it obliquely. (3) In the **lower third** at the bend of the elbow, and below the origin of all its branches; it lies between the tendon of the biceps on the outer side, and the median nerve on the inner side, and covered by the bicipital fascia and the median basilic vein.

Fig. 19.

TO SHOW RELATION OF THE ARTERY TO THE HUMERUS.



On the right hand side observe how the pressure must be directed at different parts in order to control the flow through the vessel.

IN THE MIDDLE OF THE ARM.

Superficial Guide.—The prominence caused by the inner edge of the biceps. **Position of the Arm.**—It should be held, by an assistant with the fore-arm fully extended and supinated, the upper

arm rotated outwards and well abducted and not allowed to rest on any support, as this is apt to push up the triceps and displace the vessel (HEATH). The **operator** should stand behind the arm on both sides of the body, but may, if he think it more convenient, sit between the arm and the trunk in both cases. **Incision.**—This should be about three inches long, and made on the biceps (and not exactly over the vessel) parallel with and close to its inner edge, but avoiding the basilic vein. We divide the skin, fatty tissue, and superficial fascia, and then define the inner edge of the biceps, and draw it aside and cut through the deep fascia carefully, as the basilic vein and internal cutaneous nerve are often found just below it, to the inner side of the artery, and then look for the **deep guide:** the median nerve close to the edge of the biceps, or crossing the vessel in the bottom of the wound from without inwards. I ought to state that many operators advise that the *sheath* of the biceps should *not* be opened, as the vessel can very readily be exposed and tied without doing so. Open the fascia over the median nerve, and then by means of blunt hooks draw the basilic vein and median nerve to the inner side, and the biceps to the outer side (the median nerve may be displaced to the side found most convenient), the assistant who has charge of the arm at the same time bending the elbow to relax that muscle. Separate the sheath from the surrounding structures, open it, clear the vessel from its venæ comites, and pass the needle *from* the nerve, at the same time taking care not to injure the venæ comites which often surround the vessel with anastomosing loops. The mobility of the vessel, the obliquity of the various structures, as well as the relation of the artery to the basilic vein and median and internal cutaneous nerves, makes the operation sometimes a little difficult.

RÉSUMÉ of the chief points in ligature of the brachial artery about the middle of the arm:—

1. Extend, abduct, and supinate the arm, take care of the basilic vein, and then
2. Make an incision three inches long about the middle of the arm on the edge of the biceps, and then
3. Open the deep fascia over its inner edge, flex the elbow, and displace it outwards.

4. Divide the fascia over the median nerve thoroughly so that it can be displaced easily without dragging the artery with it, but at the same time take care not to injure the sheath of the artery.
5. Clear the vessel and tie, passing the needle from the median nerve.

AT THE BEND OF THE ELBOW.—With the **arm** well abducted, and the fore-arm freely supinated and extended, the **operator,** standing on the outer aspect of the arm on both sides of the body, ascertains the position of the median basilic vein and the tendon of the biceps, and then makes an **incision** two inches in length, parallel with and a little above the vein. The incision commences half-an-inch above the level of the internal condyle of the humerus and forms an angle of 45° with the long axis of the arm; it is to the inner side of the tendon of the biceps, and must not be prolonged too far downwards lest the median cephalic vein be cut. Draw aside the median basilic vein and the internal cutaneous nerve by a blunt hook, and thus expose the bicipital fascia; divide this on a director, and then the artery is seen lying between the tendon of the biceps and the median nerve and resting on the brachialis anticus. Bend the elbow and draw the structures on each side away from the vessel, expose and open the sheath, carefully clear the vessel, and pass the needle from the nerve.

NOTE.—(1) Unless the incision be made close to the inner edge of the biceps, the operator may cut down upon the ulnar nerve with its companion, the inferior profunda artery, and mistake the latter for the brachial. (2) In one out of every five cases there are two arteries instead of one. (3) The biceps muscle has occasionally a third head of origin arising between the coraco-brachialis and the brachialis anticus, and when this is the case it crosses in *front* of the brachial artery near the spot where it is usually ligatured; in other cases a slip may be derived from the coraco-brachialis, which crosses the vessel to join the inner head of the triceps. (4) Several cases are recorded where the median nerve passed *under* the artery, instead of over it. (5) The artery, accompanied by the median nerve, sometimes passes to the inner condyle and curves round a prominence of bone (the "supra-condyloid process"), and then passes beneath or through the pronator radii teres to its usual

position in front of the bend of the elbow—a condition somewhat similar to the normal condition in many of the carnivora. In those who use crutches this vessel has occasionally been obliterated by the pressure thus caused. (6) The coraco-brachialis is inserted into the inner border of the humerus near its middle, and at this point note the following facts:—(*a*) The brachial artery lies upon it; (*b*) the median nerve crosses the artery at this point; (*c*) the internal cutaneous nerve leaves the artery here, passing forwards to pierce the deep fascia; (*d*) at this point also the ulnar nerve leaves the brachial, passing backwards; (*e*) here the brachial is nearest the humerus and is most easily compressed; (*f*) at this point the nutrient artery enters the humerus; (*g*) the inferior profunda is given off at this point; and lastly, (*h*) the brachial is usually ligatured about this region.

Branches.—(1) Muscular; (2) superior profunda, which joins and accompanies the musculo-spiral nerve; (3) inferior profunda, which accompanies the ulnar nerve; (4) nutrient to humerus; (5) anastomotic branch, which is given off about two inches above the elbow joint, and divides into two branches—one passes to the front of the internal condyle, the other passes behind the joint.

RÉSUMÉ of the operation at the bend of the elbow:—

1. Make an oblique incision beginning half-an-inch above the level of the internal condyle, parallel with the median basilic vein, through skin and superficial fascia only.
2. Do not prolong it too far down lest the median cephalic vein be divided.
3. Draw aside the vein and the internal cutaneous nerve and divide the bicipital fascia on a director.
4. Look for the artery between the tendon of the biceps and the median nerve.
5. Clear the vessel and pass the needle from the nerve.

Collateral Circulation (see Fig. 18).—This varies according to the point of ligature. At the upper part, in a general way, it is carried on by branches from the circumflex (9) and subscapular (13) arteries, anastomosing with the ascending branches of the superior profunda (14), and muscular branches through the various muscles in the neighbourhood. Ligature above the superior profunda is

sometimes followed by gangrene, on account of the anastomoses between the axillary and brachial being so scanty. Lower down we have the superior (16) and inferior (20) profundæ above, anastomosing with various branches in the general anastomoses round the elbow joint, *e.g.*, the superior profunda with the radial recurrent (22), posterior interosseous recurrent (21), and anastomotic (32); the inferior profunda (20) with the anterior (33) and posterior (34) ulnar recurrents and anastomotic (32). Besides these there is the circulation through the shaft of the humerus and muscles in the neighbourhood. It will evidently vary, therefore, according as the vessel is tied between the profunda arteries, below both, or at the bend of the elbow where it is below all the branches.

It will be well, at this point, to give a brief description of the **Anastomoses round the Elbow Joint** (see Fig. 18). There are seven vessels that take part in this anastomoses:—Three branches coming down—superior and inferior profundæ, and the anastomotic; and four branches passing upwards—radial recurrent, anterior and posterior ulnar recurrents, and the posterior interosseous recurrent. For convenience they may be divided into four groups:—1. In **front of external** condyle, anastomoses between—(*a*) superior profunda, and (*b*) radial recurrent (22). 2. In **front of internal** condyle, anastomoses between—(*a*) the anastomotic branch (32); (*b*) anterior ulnar recurrent (33); and (*c*) inferior profunda (20). 3. **Behind external** condyle, anastomoses between—(*a*) the anastomotic branch; (*b*) interosseous recurrent; and (*c*) the superior profunda (21) 4. **Behind internal** condyle, anastomoses between—(*a*) the anastomotic branch (32); (*b*) posterior ulnar recurrent (34); and (*c*) the inferior profunda (20).

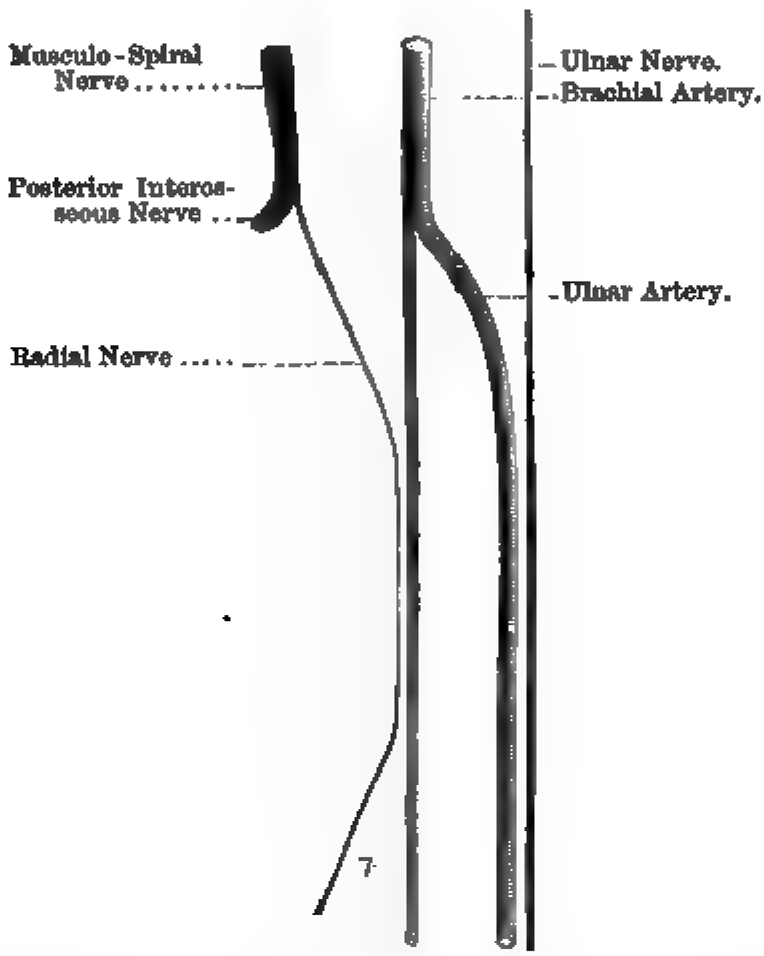
RADIAL ARTERY.

This vessel, like the brachial, of which it is the proper continuation, is quite superficial. **Origin.**—From the bifurcation of the brachial at the bend of the elbow. **Extent.**—From its point of origin till it ends in the deep palmar arch. **Course.**—A line drawn from the centre of the hollow in front of the elbow joint to the inner side of the anterior aspect of the styloid process of the radius will roughly indicate its course. **Relations.**—In *front*—Skin, superficial and deep fascia, cutaneous nerves (especially the external

cutaneous which lies over the vessel at the point where the "pulse" is usually felt) and vessels, etc., and it may be slightly overlapped at the upper part by the supinator longus. On the *inner side*—(1) Pronator radii teres, above; (2) flexor carpi radialis, below. On the *outer side*—(1) Supinator longus; (2) radial nerve (but only about the middle third of the vessel). *Behind*—(1) Tendon

Fig. 20.

RELATION OF ULNAR AND RADIAL ARTERIES AND NERVES.



7. Radial Artery.

of biceps; (2) supinator brevis; (3) pronator radii teres; (4) flexor sublimis (radial head); (5) flexor longus pollicis; (6) pronator quadratus; (7) end of the radius. Note that at the wrist it lies between the tendons of the supinator longus and the flexor carpi radialis, and that the nerve is only in relation to the *middle third* of its outer side (Fig. 20).

The vessel may be ligatured—1. In the **upper third** of its course, where it lies between the supinator longus and the pronator radii teres, resting on the tendon of the biceps, supinator brevis, and part of the insertion of the pronator radii teres. In a muscular arm the supinator longus will overlap the vessel considerably. The radial nerve has no direct relation to this part of the vessel. **Guide.**—The line that indicates the course of the vessel, or the inner edge of the supinator longus muscle; find the tendon of this muscle at the wrist, and trace it up towards the bend of the arm. The **arm** should be moderately abducted, and the fore-arm fully supinated, and either resting on the table or supported by an assistant; when the muscles are exposed, then the assistant may flex the elbow to allow of them being held aside by blunt hooks in the charge of another assistant. The **operator** stands on the outer side of the arm on both sides of the body. **Incision.**—This should be two or three inches in length, and parallel with the inner edge of the muscle. Divide the skin and superficial fascia, define the inner edge of the supinator longus, and divide the layer of deep fascia under the muscle, draw it a little outwards, and the pronator radii teres inwards, and the artery will be seen immediately below this. Separate the venæ comites, clear the artery, and ligature. As the radial nerve has no close relation to this part of the vessel, it matters but little how the needle is passed.

RÉSUMÉ:—

1. Make an incision two inches long in the course of the vessel, avoiding as far as possible the large subcutaneous veins.
2. Divide the deep fascia and define the edge of the supinator longus.
3. Flex the fore-arm and wrist, separate the supinator longus and pronator radii teres.
4. Clear the artery and ligature.

2. In the **middle third**, where it lies between the supinator longus and the fleshy belly of the flexor carpi radialis, resting on the lower part of the insertion of the pronator radii teres, flexor sublimis, and flexor longus pollicis. The radial nerve lies on the outer side of, and close to, the vessel. The **guide** to the artery

and the steps of the operation are almost precisely similar to those of the previous operation. The **incision** need not be quite so long, and, as the nerve lies on the outer side and close to the vessel, the needle should be passed *from* the nerve.

3. In the **lower third**, where it lies between the tendons of the supinator longus and the flexor carpi radialis, resting on the flexor longus pollicis, pronator quadratus and the end of the radius. The radial nerve has by this time left the artery to pass to the back of the hand, and therefore lies considerably to its outer side. Make an **incision** two inches in length in the middle of the space, bounded by the supinator longus on the outer side, and the flexor carpi radialis on the inner side; at this point the artery may be felt pulsating. Divide the skin, fascia, cutaneous vessels, and nerves (usually one of the terminal branches of the musculo-cutaneous nerve lies over the artery). When the deep fascia is divided, the artery is seen with its venæ comites; avoid these in clearing the vessel and in passing the needle. Complete the operation in the usual manner, passing the needle from the side most convenient.

4. At the **root of the thumb** (in the "*anatomist's snuff-box*"). From the anterior aspect of the radius, the artery passes round the root of the thumb to the first interosseous space, where it disappears between the two heads of the first dorsal interosseous muscle *(abductor indicis)*; it *lies on* the external lateral ligament of the wrist joint, scaphoid and trapezium, *covered by* the skin and fascia, the large radial vein, filaments of the radial nerve, and the three extensors of the thumb—ossis metacarpi, primi internodii, and secundi internodii. It is accompanied by its venæ comites and a twig from the musculo-cutaneous nerve. With the hand held by an assistant in a position midway between pronation and supination, the operator makes an **incision** an inch and a half in length from the posterior part of the root of the styloid process of the radius to the base of the metacarpal bone of the thumb, external to the large vein, and almost parallel with the tendon of the extensor secundi. The first incision divides the superficial structures, but should not injure the vein already mentioned. Divide the deep fascia, hold the tendons aside, when the artery with its venæ comites and a small nerve will be seen crossing the wound obliquely. Separate the venæ comites and tie the vessel in the usual manner.

PECULIARITIES.—Not unfrequently the radial takes its origin from the brachial, sometimes from the axillary. It has been seen more superficial than usual, lying above the deep fascia and the supinator longus muscle.

Branches.—Its branches in the **fore-arm** are—(1) The radial recurrent; (2) superficialis volæ. This vessel usually arises just as the radial is about to wind round the wrist; it is usually small, and ends in the muscles of the thumb, but sometimes it is as large as the continuation of the radial, and arises much higher up; under these circumstances, the two run side by side for a little way, and form what has been called the "*double pulse.*" (3) Muscular; (4) anterior carpal. At the **wrist**—(1) Posterior carpal; (2) metacarpal, or *first dorsal interosseous;* (3) dorsales pollicis; (4) dorsalis indicis. In the **hand**—(1) Princeps pollicis; (2) radialis indicis; (3) perforating; (4) interosseous.

Collateral Circulation (see Fig. 18). — Chiefly by the ulnar artery and its branches through the palmar arches (31, 31*a*). The anastomoses here are so free that, if the radial is wounded, a ligature must be applied on both sides of the wound.

ULNAR ARTERY.

Origin.—From the bifurcation of the brachial at the bend of the elbow. **Extent.**—From its point of origin till it ends in the superficial palmar arch. **Course.**—It first passes downwards and inwards, and then straight downwards. The course of the straight part may be indicated by a line drawn from the inner condyle of the humerus to the inner side of the pisiform bone. **Relations.**—This vessel, unlike the radial, is at first very deeply placed. In *front*—(1) The superficial structures; (2) crossed by the median nerve at its upper part; (3) the following four muscles—(*a*) pronator radii teres, (*b*) flexor carpi radialis, (*c*) palmaris longus, (*d*) flexor sublimis digitorum. *Behind*—(1) Brachalis anticus; (2) flexor profundus digitorum. To its *inner side*—(1) Flexor carpi ulnaris; (2) ulnar nerve (for its lower two-thirds). To its *outer side*—The flexor sublimis digitorum.

NOTE.—At the wrist it lies between the tendons of the flexor sublimis digitorum and the flexor carpi ulnaris, and that the nerve is on its inner side for the lower two thirds (see Fig. 20). It may

be ligatured at its middle or lower third; the upper third is too deeply situated to admit of ligature except in the case of a direct wound of the artery.

1. **At its Middle Third.**—**Guide**—The inter-muscular septum and groove between the fleshy bellies of the flexor carpi ulnaris, and the flexor sublimis digitorum; search for the tendon of the flexor carpi ulnaris and follow it up towards the bend of the elbow and make an **incision** two or three inches in length, either parallel with the edge of the flexor carpi ulnaris or somewhat obliquely across its course. We may also use the line that marks the course of the lower two thirds of the artery as our guide. The position of the **arm** is the same as that for ligature of the radial, and the **Surgeon** stands on the outer side of the limb in both cases. Divide the skin and superficial fascia only by the first incision, and then search for the inter-muscular septum between that muscle and the flexor sublimis, and forcibly separate them; this is the first inter-muscular space found in passing from the posterior edge of the ulna round the front of the fore-arm. At this stage an assistant should flex the wrist to allow the muscles on each side to be held aside with blunt hooks by another assistant. At the bottom of the wound the ulnar nerve is exposed, and the artery, with its venæ comites on each side, will be found to the outer side of the nerve. Pass the needle from the nerve, and complete the operation in the usual manner.

RÉSUMÉ:—

1. Make a slightly-oblique incision across the course of the vessel well to the inner side of the arm.
2. Divide the deep fascia, and find the first inter-muscular space from the ulnar edge of the arm.
3. Separate the flexor carpi ulnaris from the flexor sublimis.
4. Flex the wrist and fore-arm, hold the sides of the wound apart, when the artery will be found between the two layers of muscles.
5. The nerve is seen to the inner side of the artery.
6. Clear the vessel and pass the ligature from the nerve.

2. **At its Lower Third.**—Here the artery is quite superficial, and lies between the tendons of the flexor carpi ulnaris and flexor

sublimis digitorum. **Superficial Guide**—Tendon of the flexor carpi ulnaris; the pisiform bone, into which it is inserted, forms a sure guide to the tendon. Or the line that marks the course of the vessel may be taken as guide. **Incision.**—Make an incision two inches long parallel with the tendon, but a little external to it. By this incision the skin and superficial fascia are divided; then divide the inter-muscular layer of deep fascia, flex the wrist and draw aside the tendons, when the artery and nerve will be exposed to view. The **Deep Guide** is the ulnar nerve, which lies immediately internal to the artery. Bend the wrist, and draw the tendon of the flexor carpi ulnaris to the inner side, and then isolate the vessel, taking care of the venæ comites, and ligature in the usual manner, the needle being passed *from* the nerve, which lies to its inner side.

PECULIARITIES.—The artery not unfrequently arises from the brachial, sometimes from the axillary. When its origin is high up it usually passes superficially to the flexor muscles of the fore-arm, just beneath the deep fascia.

Branches.—The more important branches are—(1) Anterior, and (2) posterior ulnar recurrents; (3) common interosseous, and (4) profunda branch, which is given off just beyond the pisiform bone, and dips down between the abductor minimi digiti and flexor brevis minimi digiti, and anastomoses, with the radial, completing the deep palmar arch. For the termination of the recurrent branches see "Anastomoses round the Elbow Joint" (page 102). Other branches are (5) anterior and (6) posterior carpals, and (7) digital.

Collateral Circulation (see Fig. 18).—Chiefly from the radial and its branches through the palmar arches (30, 31*a*).

PALMAR ARCHES.

(*a*) **Superficial Arch** (see Fig. 18, *31a*).—This is the direct continuation of the ulnar artery. It forms an arch with the convexity downwards, and is completed on the radial side by the *superficialis volæ* branch of the radial artery, or, probably more frequently, by the *radialis indicis* branch of the same artery. It lies beneath the integumentary structures and palmar fascia, and rests on the digital arteries and nerves and tendons of the flexor sublimis digitorum.

(*b*) **Deep Palmar Arch** (see Fig. 18, *31*).—This is the direct continuation of the radial artery, and is completed on the ulnar side by the *profunda* branch of the ulnar artery. It lies deeply, and, in addition to the structures covering the superficial arch, is covered by the digital nerves and arteries, and tendons of the superficial and deep flexors of the fingers and some of the muscles of the little finger and thumb. It rests on the palmar interossei and metacarpal bones near their carpal ends.

Position of the Arches.—**The Superficial**—Extend the thumb till it lies at right angles to the hand, and then draw a line across the palm on a level with its lower margin; this line should touch the lowest part of the convexity of the arch. The **Deep Arch** lies fully a finger's breadth nearer the carpus. To expose the superficial arch in its ulnar portion, make an **incision** over it an inch in length and slightly oblique, from the radial to the ulnar side, with its centre opposite the ring finger, and parallel with the palmar outline of the ball of the thumb.

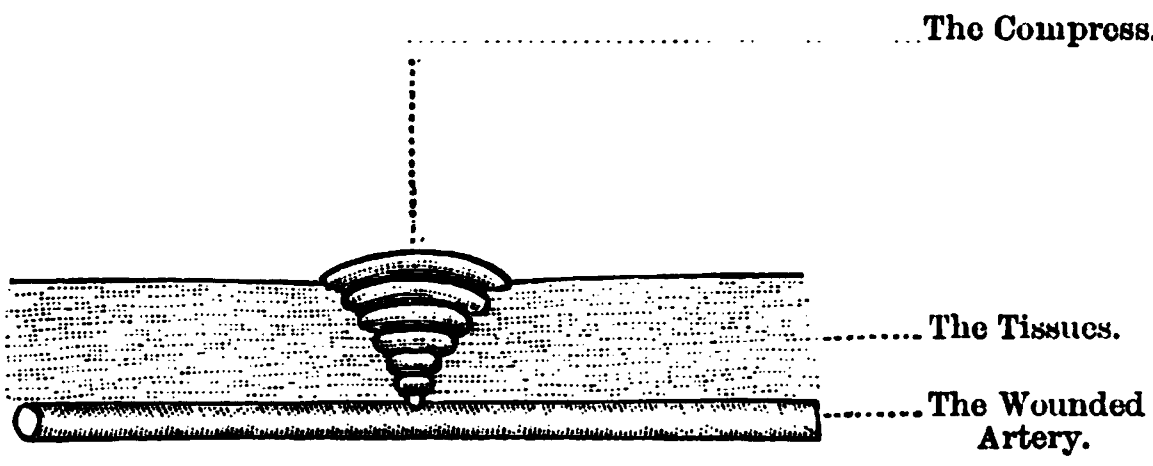
Branches.—(*a*) From **Superficial Arch** are given off—(1) Four digital arteries which supply the little finger, the ring finger, middle finger, and the ulnar side of the index finger. These vessels bifurcate half-an-inch above the clefts between the fingers. (2) The deep or communicating branch; (3) recurrent branches which pass upwards towards the annular ligament. (*b*) From the **Deep Arch**—(1) Recurrent branches which ascend and anastomose with branches from the anterior carpal arch; (2) superior perforating, three in number, which pass backwards through the upper part of the last three interosseous spaces, to anastomose with the dorsal interosseous arteries; (3) the palmar interosseous arteries, three in number, which lie in front of the palmar interosseous muscles, and anatomose at the clefts of the fingers, with the digital branches from the superficial arch. The **Anterior Carpal Arch** is formed by the anterior carpals of radial and ulnar; it anastomoses on the one hand with the anterior interosseous, and on the other with the deep palmar arch. The **Posterior Carpal Arch** is formed by the posterior carpals of radial and ulnar. From this arch are given off *descending* branches, the dorsal interosseous arteries for the third and fourth interosseous spaces, which anastomose with the posterior perforating branches from the deep palmar arch; it also gives off ascending

branches to anastomose with the branch of the anterior interosseous artery, found on the posterior surface of the fore-arm. The **Deep Palmar Arch communicates** with—(1) The anterior interosseous and anterior carpal arch; (2) digital branches of the superficial arch; (3) with branches of the posterior carpal arch. It will be seen, therefore, that the various vessels about the wrist and palm anastomose with great freedom.

If both the radial and ulnar arteries are ligatured, the blood reaches the palm from the anterior and posterior interosseous arteries through the anterior and posterior carpal arches, which communicate with the deep palmar arch. There is usually a small artery accompanying the median nerve into the palm (" *comes nervi mediani* "), but this branch is sometimes of large size, and joins the

Fig. 21.

THE GRADUATED COMPRESS.



superficial palmar arch. It arises from the anterior interosseous, and it is well to bear in mind the possible existence of this branch. Hence it is not advisable to tie the radial and ulnar arteries for wounds of the palmar arches, as the blood will still reach the wound. It is better to apply a graduated compress or plug (Fig. 21), together with acute flexion of the wrist and elbow joints, as we wish, as far as possible, to avoid an extensive wound of the palm, on account of the resulting cicatrix. The **objections** to the palmar incision are the following:—(1) It would have to be more extensive than in other parts of the body, because incisions made into the palm of the hand and the sole of the foot show but little tendency to gape, as the skin is firmly adherent to the fascial

textures. (2) The resulting cicatrix, especially in the hand of a working-man, is subjected to constant irritation, and probably fifteen to twenty years of such irritation will result in an epithelioma, besides frequently being painful and showing a tendency to ulcerate in the meantime.

Should this be insufficient to control the hæmorrhage, it is better at once to ligature the brachial, as it is more effectual and not more difficult than the double operation of tying the radial and ulnar arteries above the wrist. As, however, in many cases the artery is only *wounded*, it is evident that before resorting to severe measures, one should make certain that the vessel is completely cut across. This can easily be done through the original wound, and then very likely the artery will contract and retract sufficiently to allow the blood to clot and stop further hæmorrhage. The deep palmar arch, however, may be readily ligatured from the dorsum, after excision of the upper end of the third metacarpal bone (DELORME).

In the palm, the digital arteries and nerves lie on the interosseous muscles *between* the metacarpal bones, and, therefore, incisions in this region should be made over these bones. The arteries are superficial to the nerves, and they bifurcate fully half-an-inch from the clefts of the fingers, or about the level of the fold in the palm formed by the flexion of the fingers at the metacarpo-phalangeal joints. The most internal branch, however, does not bifurcate, but runs along the ulnar side of the little finger; the other branches run along the sides of the fingers, nearer the anterior than the posterior aspect, and must be avoided should it be necessary to make incisions along the sides of the fingers. The relation between the nerves and the arteries differs in the palm and in the fingers: in the palm the arteries are superficial to the nerves, but in the fingers they are deeper than the nerves.

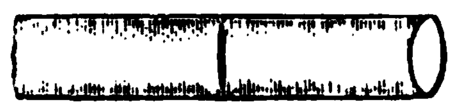
RÉSUMÉ of the methods to be adopted in the treatment of cases of hæmorrhage from the palmar arches:—

1. Make sure that the artery is more than *wounded*, see that it is completely divided; for, true to one of Nature's great laws, the very agencies which are appointed for the conservation of the individual become, when perverted, his destruction. Hence, when only wounded

(Fig 22), the contraction and retraction serve to make the wound larger (Fig. 23), but when completely divided they seal up the ends of the vessel. This is

Fig. 22.

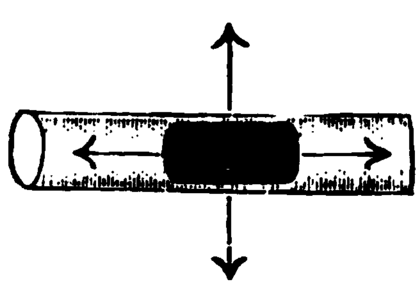
WOUNDED ARTERY.



best seen in cases where the wound is transverse in direction; it is less marked when the wound is oblique, and least of all when it is longitudinal.

Fig. 23.

WOUNDED ARTERY.



To show how the attempts at contraction and retraction open up the wound.

2. Next try the graduated compress. First command the brachial artery so as to stop all bleeding, clear out the wound, and apply the pads of lint *dry*, because if applied moist they act as a poultice and encourage bleeding. The compress must be conical in shape, the narrow end resting against the bleeding vessel, the pads becoming larger and larger as the surface is approached; then apply a mass of antiseptic wool, and a bandage over all. The compress may be kept on for twelve hours. In using this method for the artificial arrest of hæmorrhage, it is necessary that there should be something firm behind the vessel; in the case of the palmar arches we have the metacarpal bones. The pressure exercised need not be great; it has been found that pressure equal to a quarter of an ounce, properly applied, will stop the bleeding.

3. Next, with or without the above, use acute flexion of the elbow joint over a pad of wool, coupled at the same time with flexion of the wrist joint.
4. Lastly, when everything else fails, ligature the brachial artery in the middle of the arm. It might be tied at the bend of the elbow, but it is better to avoid a cicatrix near the flexure of a joint. Take care that there are not two arteries instead of one to tie.

Many objections are urged against the graduated compress—that it is the cause of sloughing, septic inflammation among the tendon sheaths, etc. But the pressure required is not great, and it is possible to use an antiseptic compress. An effort can also be made, if possible without enlarging the wound, to secure the bleeding ends by forcipressure, leaving the forceps attached for twenty-four hours; but flexion of the joints, with elevation of the limb, as above described, will probably be found sufficient. Compression of the radial and ulnar arteries by means of acupressure needles has also been recommended.

CHAPTER X.

ARTERIES OF THE ABDOMEN.

The Abdominal Aorta.—This vessel has been tied several times immediately above its point of bifurcation, or between that point and the origin of the inferior mesenteric artery, but without success; all the patients having died within periods varying from a few hours to ten days, the greater number having died within twenty-four hours. It is usually tied behind the peritoneum, although Sir ASTLEY COOPER, who was the first to tie the vessel, made his incision through the peritoneum. Aneurism usually occurs near the cœliac axis, or at the bifurcation; the genito-crural, anterior crural, and external cutaneous nerves may be pressed upon, giving rise to pain in the course of the nerves. The aneurism must be diagnosed from a mass of fæces in the transverse colon, lordosis pushing the artery forwards, from masses of enlarged glands, and abdominal tumours over the aorta. **Origin.**—It is the direct continuation of the descending thoracic aorta. **Extent.**—From the front of the body of the last dorsal vertebra to the left side of the body of the fourth lumbar vertebra, where it bifurcates into the common iliacs, a little to the left of the mesial line. Its point of bifurcation corresponds very nearly to the highest part of the crest of the ilium, or about an inch below and a little to the left of the umbilicus. **Course.**—From the middle line, at its origin, to a point a little to the left of the same line at its bifurcation; or, from the apex of the arch formed by the tenth rib on the left side, to a point slightly internal to the anterior superior iliac spine.

Relations.—In *front*—(1) The transverse part of the duodenum; (2) peritoneum; (3) aortic plexus of nerves; (4) lesser omentum and stomach; (5) branches of cœliac axis and solar plexus; (6) splenic vein; (7) pancreas; (8) left renal vein; (9) mesentery and small

intestines. On its *left side*—The left gangliated cord of the sympathetic and left semi-lunar ganglion. On its *right side*—(1) The inferior vena cava; (2) vena azygos major; (3) receptaculum chyli. *Behind* it we find—(1) The left lumbar veins; (2) the vertebral column and thoracic duct; (4) right crus of diaphragm; (5) right semi-lunar ganglion.

INCISIONS.—First form, through the peritoneum (Sir ASTLEY COOPER). Make a straight incision four or five inches long in the middle line, curving round the umbilicus, which should correspond to the centre of the incision. Divide the skin, superficial fascia, and aponeurosis forming the linea alba; then stop every bleeding vessel, and after this cut through the transversalis fascia, extra-peritoneal fat and peritoneum. Push the small intestines to the right side, and again divide the peritoneum as it covers the aorta; carefully separate the aortic plexus from the vessel, isolate it also from the inferior vena cava, which lies to its right side, and pass the needle from the vein.

Second form, without wounding the peritoneum (MURRAY). Make a semi-lunar incision five inches long on the left side of the abdomen, commencing a little below the anterior superior iliac spine, and fully an inch above Poupart's ligament, and carry it at first upwards and outwards, and then curving slightly forwards towards the umbilicus, end a little below the tenth rib. The **Structures divided** and the method of operating are similar to those described under ligature of the common iliac arteries (see page 136). The **operator** stands on the right side.

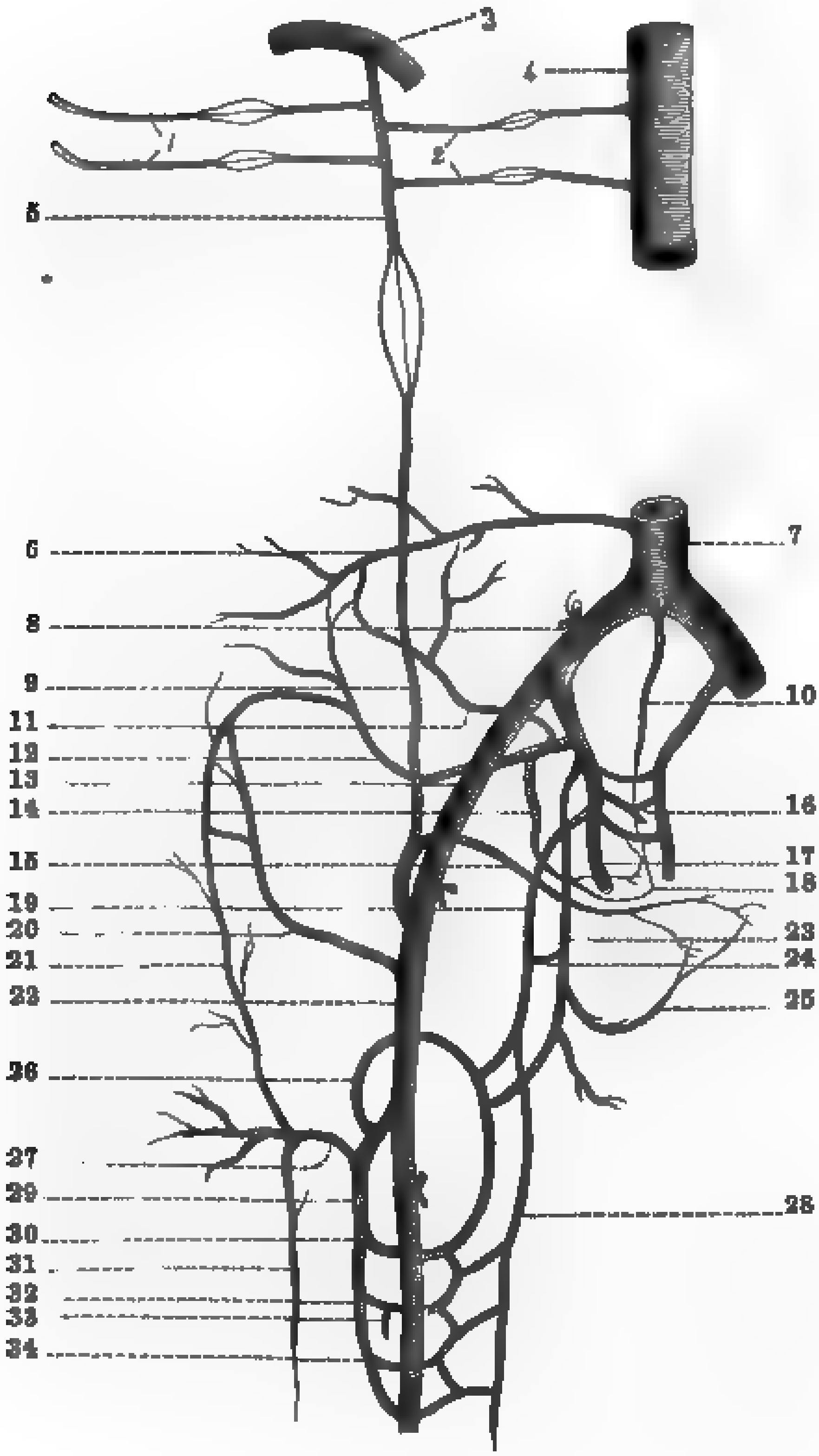
Branches.—The most important branches, from a surgical point of view, are:—(1) The cœliac axis, the origin of which corresponds to a point four or five inches above the umbilicus; it is a short trunk, and soon divides into the gastric, hepatic, and splenic; (2) the superior mesenteric which arises about a quarter-of-an-inch below the cœliac axis; (3) the renal arteries, which correspond to a point three and a half inches above the umbilicus; and (4) the inferior mesenteric, about one inch above the umbilicus.

Collateral Circulation (see Fig. 24)—1. The deep epigastric branch (9) of the external iliac anastomosing with the terminal branches of the internal mammary branch (5) of the first part of the subclavian and the aortic intercostals (2). 2. The deep circumflex

Fig. 24.

COLLATERAL CIRCULATION OF THE ABDOMEN.

(After SMITH and WALSHAM.)



Explanation of Fig. 24.

1. Thoracic branches of the axillary.
2. Anastomoses between the internal mammary and the aortic intercostals.
3. Subclavian artery.
4. Aorta.
5. Internal mammary.
6. Last lumbar artery.
7. Aorta.
8. The common iliac.
9. The deep epigastric.
10. The middle sacral artery.
11. Ilio-lumber artery.
12. Gluteal artery.
13. The external iliac.
14. The lateral sacral.
15. Pubic branch of deep epigastric.
16. Anastomoses between the visceral branches of the internal iliacs.
17. Pudic artery.
18. Anastomosis between the lateral and the middle sacrals.
19. Sciatic artery.
20. Deep circumflex iliac.
21. Ascending branch of the external circumflex.
22. Femoral artery.
23. Obturator artery.
24. Anastomosis between obturator and sciatic.
25. Pubic branch of obturator anastomosing with the pubic branch of the deep epigastric.
26. Internal circumflex.
27. External circumflex.
28. Comes nervi ischiadici.
29. Profunda artery.
30. First perforating.
31. Descending branch of the external circumflex.
32. Second perforating.
33. Nutrient artery of femur.
34. Third perforating.

iliac branch (20) of the external iliac and ilio-lumbar (11) of the internal iliac anastomosing with the lower intercostals (2) and lumbar arteries (6) of the aorta. 3. The superior hæmorrhoidal termination of the inferior mesenteric anastomosing with the lateral sacral (14) and middle hæmorrhoidal branches of the internal iliac and middle sacral (10) of the aorta. 4. The extra-peritoneal plexus of TURNER, which he describes as a wide-meshed plexus of small arteries lying in the fat outside the peritoneum. Above, it communicates with the perforating branches of the renal arteries, small twigs of the capsular, spermatic, colic, and pancreatic arteries, and below with the lower lumbar arteries, and with the ilio-lumbar, circumflex iliac, and epigastric branches of the iliac arteries. 5. Spermatic artery from the aorta anastomosing with the branches of the internal iliac to the ureter and vas deferens. 6. In the female, the ovarian anastomosing with the uterine.

In treating aneurism of this vessel by **Compression**, the vessels of the kidney, the hypogastric plexus, the intestines, and the peritoneum are all apt to be pressed upon, giving rise to the presence of blood and albumen in the urine, suppression of urine, and peritonitis. Take care that the bowels are empty, and place a soft, hollow sponge below the tourniquet, and if the patient show signs of syncope slacken; vomiting, etc., may make it slip off the vessel. LORETA has cured an abdominal aneurism by passing wire into the sac through a small canula.

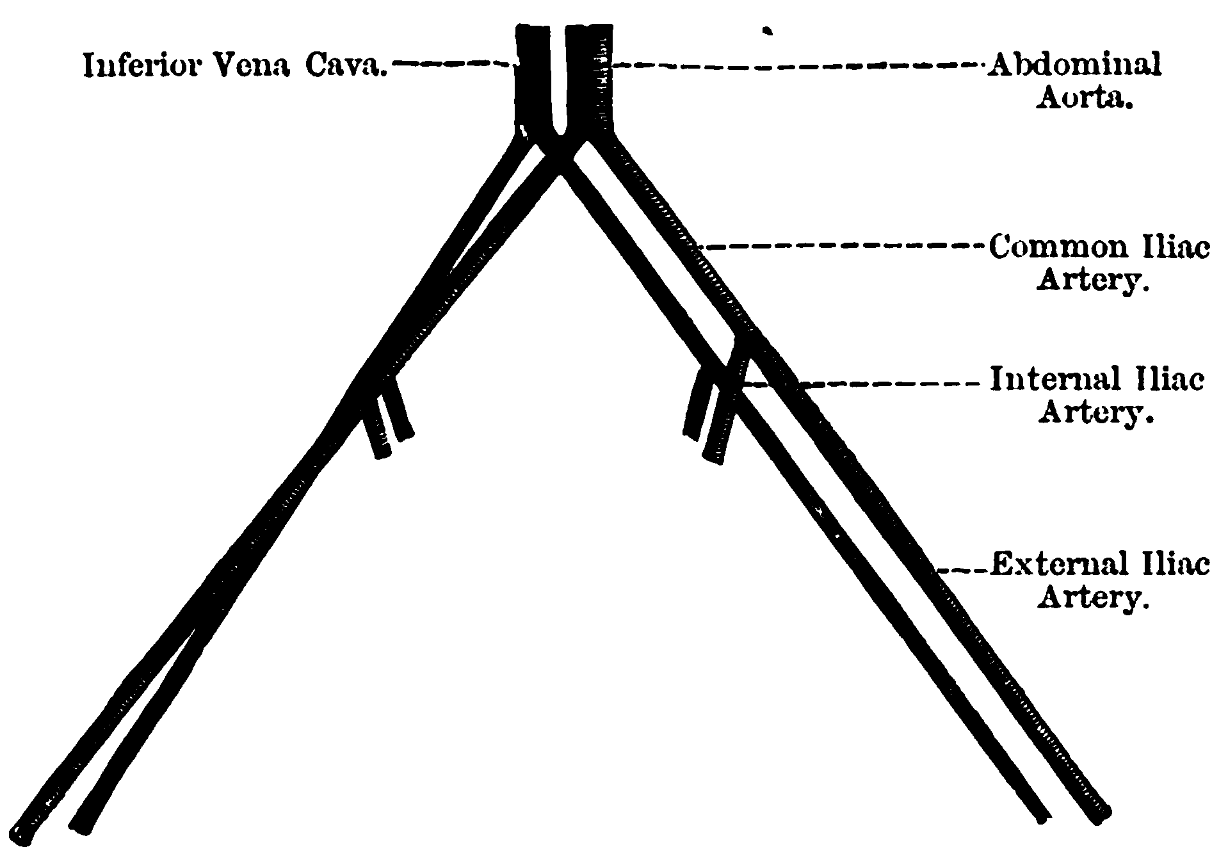
COMMON ILIACS.

Origin.—From the bifurcation of the abdominal aorta at the left side of the body of the fourth lumbar vertebra. **Extent.**—From its point of origin to the lumbo-sacral articulation, where it divides into internal and external iliac arteries. Each common iliac is about two inches in length, but varies from three-quarters of an inch to three inches; the *right* is necessarily a little longer than the left, because the point of division of the abdominal aorta is slightly to the left of the median line. The right is also somewhat larger than the left. **Course.**—Its course corresponds to the upper third of a line drawn from a point three-fourths of an inch below and a little to the left of the umbilicus, to a point midway between *the symphysis* pubis and the anterior superior iliac spine.

Relations.—The relations differ somewhat on the two sides. **Right Common Iliac.**—This vessel *rests against* its own vein at the lower part, and at the upper part crosses the vein of the opposite side. In *front* there are—(1) The small intestines (end of the ileum and cæcum); (2) peritoneum; (3) sympathetic nerves; (4) crossed by the ureter near its termination (on the right side, however, the ureter often crosses the external iliac, not the common). On its *outer side* are—(1) The right common iliac vein; (2) the commencement of the vena cava inferior. Its *internal* relations are unimportant. **Left Common Iliac.**—The left common iliac *rests on* the psoas magnus. In *front* are—(1) The rectum and the sigmoid flexure; (2) peritoneum; (3) sympathetic nerves; (4) crossed by the ureter near its termination, and the inferior mesenteric vessels.

Fig. 25.

ILIAC ARTERIES AND VEINS.



On its *outer side* is the psoas magnus. On its *inner side*, the left common iliac vein. The relation of the common iliac veins to their corresponding arteries should be noted (Fig. 25). The inferior vena cava is formed by the union of the two common iliac veins on the *right* side of the vertebral column, and both veins lie on the *right* side of, and on a plane posterior to, their corresponding arteries. On the *right* side the vein is at first

beneath and then to the outer side of the artery. The *left* vein lies entirely to the inner side of the left artery, and then passes beneath the right common iliac artery to unite with the vein of the opposite side in the formation of the inferior vena cava, at the right side of the fifth lumbar vertebra. The relation of the veins is a great trouble, and complicates the operation very much, more especially on the right side. In ligature of the arteries of the abdomen, the bowels must be well cleared out, and all hair shaved off the abdominal wall near the site of the incision. In cases of flatulence after the operation use a soap and water enema, containing a tablespoonful of turpentine, to dispel it.

Position of Patient.—On his back with his shoulders raised, his thighs somewhat flexed, and a small pillow under the loin of the side to be operated upon. The **operator** stands on the side to be operated upon. An **assistant** at first simply keeps the abdominal muscles moderately tense, but during the later stages of the operation, when the peritoneum is stripped from the iliac fossa, he must be prepared to turn the patient round a little more on the sound side, and then with two broad copper spatulæ to hold the abdominal muscles, the peritoneum, and intestines out of the way of the operator, for the wound is deep, and the intestines are apt to roll back into it and embarrass the operator.

Incision.—Make a semi-lunar incision about five inches in length, beginning about an inch below and an inch and a half internal to the anterior superior iliac spine, at first passing upwards and outwards for two and a half inches, and then upwards and slightly inwards towards a point midway between the umbilicus and the ensiform cartilage, as far as may be deemed necessary. **Parts cut through**—(1) Skin; (2) superficial and deep fascia; (3) the aponeurosis of the external oblique muscle; (4) internal oblique; (5) transversalis muscle; (6) then the dull white transversalis fascia—in dividing this fascia, raise a small part at the *lower end* of the wound with the forceps, and make a small incision with the edge of the knife held horizontally, just as in opening the sheath of an artery, and afterwards enlarge this opening with a probe-pointed bistoury, a finger being introduced and the peritoneum detached, or, perhaps better, open it on Spence's hernia director. The special advantages of this director for the operation under consideration are that it is

broad and flat, with the edges well rounded, and has a very blunt point, so that it is not likely to injure the peritoneum or intestines during its introduction; and, further, the groove does not go quite up to the end, so that even should the peritoneum fold a little over its end it is not likely to be injured. This care is necessary in opening the transversalis fascia lest the peritoneum be wounded; it may, if preferred, be torn with the fingers instead of using the director and knife. The patient is now to be turned well over on the sound side, and the peritoneum is then separated carefully from the iliac fossa until the brim of the true pelvis is reached and the external iliac found, which will guide to the parent trunk, or the promontory of the sacrum and sacro-iliac synchondrosis may be taken as the guides, if the artery is approached from above. The position of the spermatic vessels and the genito-crural nerve as they cross the external iliac must be kept in mind, and also the ureter, which crosses the end of the common or the beginning of the external iliac; but the ureter and spermatic vessels are usually more or less adherent to and follow the peritoneum as it is stripped up and pressed forwards. The needle should be passed *from* the vein — that is, in ligature of both vessels, from right to left. The clearing of the vessel is a difficult proceeding, but it must be done as carefully and well as possible by the finger nail or director. Some use an ordinary needle, while others prefer the helix or rectangular one; on account of the depth of the vessel the needle had better be passed threaded. The incision must not be carried too low down or too far forwards, lest the deep circumflex iliac or the deep epigastric arteries be wounded, or even the structures passing through the internal abdominal ring. A branch of the deep circumflex iliac (or the artery itself) will be found between the transversalis and the internal oblique muscle, and must be secured at once. This vessel also serves as a useful landmark indicating the depth to which the incision has been carried.

Ligature of the common iliac may be rendered necessary on account of — (1) Aneurism of the external or internal iliacs; (2) hæmorrhage from the same vessels, either as the result of a wound (*e.g.*, a gunshot wound or stab) or a surgical operation; (3) secondary hæmorrhage after amputation of the upper part of

the thigh. The operation is in itself a serious one, and in addition to the dangers dependent on the magnitude of the operation and the vessel tied, there is a further risk of inducing fatal peritonitis. The form of the incision will vary according to the point at which we wish to apply the ligature, and also upon the size of the aneurism. In every case the centre of the incision should be opposite to the point at which we wish to secure the artery.

Collateral Circulation (see Fig. 24).—1. The deep epigastric branch (9) of the external iliac anastomosing with the internal mammary branch (5) of the subclavian and the aortic intercostals (2). 2. The deep circumflex iliac branch (20) of the external iliac and the ilio-lumbar (11) of the internal iliac anastomosing with the lower intercostals (2) and lumbar branches (6) of the aorta. 3. The lateral sacral (14) from the internal iliac anastomosing with the middle sacral (10) of the aorta and the superior hæmorrhoidal of the inferior mesenteric. 4. The pubic branch of the deep epigastric (15) with the pubic branch of the obturator (25). 5. The visceral branches of the internal iliac of the side tied anastomosing with the corresponding branches of the opposite side (16).

THE INTERNAL ILIAC.

Origin.—From the bifurcation of the common iliac at the lumbo-sacral articulation. **Extent and Course.**—From its point of origin it passes down almost immediately into the pelvis, and at the level of the great sacro-sciatic notch it divides into anterior and posterior trunks, which supply the pelvic walls and viscera. It is a short, thick vessel, about an inch and a half in length (but may vary from half-an-inch to three inches), and is much smaller than the external iliac. In the **fœtus** the internal iliac is called the hypogastric artery, and is twice as large as the external. It carries the blood from the fœtus to the placenta to be purified, and might, therefore, be looked upon in the same light as the pulmonary artery in the adult. Outside the belly of the child in utero the two vessels twine round the umbilical vein, and are known as the umbilical arteries. After birth the greater part of the vessel is obliterated, and only remains as a fibrous cord; a small part of its root, however, remains pervious, and is known as the superior vesical artery. **Relations.**—In *front* are—(1) The peritoneum;

(2) it is crossed by the ureter. *Behind* are—(1) The internal iliac vein; (2) the lumbo-sacral cord; (3) part of the pyriformis. On the *outer side* it rests against the psoas magnus and external iliac vein. To its *inner side*, at the upper part, is the internal iliac vein (the internal iliac veins both lie internal to their corresponding arteries) (see Fig. 25). The steps in the operation for the ligature of this vessel are precisely similar to those for the ligature of the common iliac (see page 136); and the bifurcation of the common iliac being found, the internal iliac is traced from it down into the pelvis. Great care is necessary, when the artery is exposed, in passing the ligature, on account of the close relation of—(1) The ureter (which crosses it, but is usually turned aside with the peritoneum); (2) the external iliac vein, on its outer side; and (3) the internal iliac vein, on its inner side, or behind it.

BRANCHES.—(*A*) From the **Anterior division**—1. Visceral, to pelvic viscera—(*a*) The superior vesical—this vessel is found in the posterior false ligament of the bladder, and gives off the *artery to the vas deferens;* (*b*) the inferior vesical; (*c*) the middle hæmorrhoidal—this vessel usually springs from the inferior vesical. In the female there are two additional arteries—uterine and vaginal. 2. Parietal, to walls of pelvis—(*a*) Obturator, (*b*) pudic, (*c*) sciatic. (*B*) From **Posterior division** they are all parietal—(*a*) Gluteal, (*b*) ilio-lumbar, (*c*) lateral sacral.

Collateral Circulation (see Fig. 24).—1. Middle sacral (10), from the aorta, anastomosing with the lateral sacral (14), from the internal iliac. 2. Superior hæmorrhoidal, from the inferior mesenteric, anastomosing with the middle hæmorrhoidal, from the internal iliac, and inferior hæmorrhoidal from the pudic. 3. The sciatic (19), from the internal iliac, anastomosing with the internal circumflex branch of the profunda (26), from femoral. 4. The gluteal (12), from the internal iliac, anastomosing with the ascending branch of the external circumflex (21), from the profunda. 5. The pubic branch of the deep epigastric (15), anastomosing with the pubic branch of the obturator (25). 6. The ilio-lumbar (11), from the internal iliac, anastomosing with the lower lumbar arteries (6), and deep circumflex iliac (20). 7. The other visceral branches of the internal iliac, not included in the above list, with the corresponding branches from the other side (16).

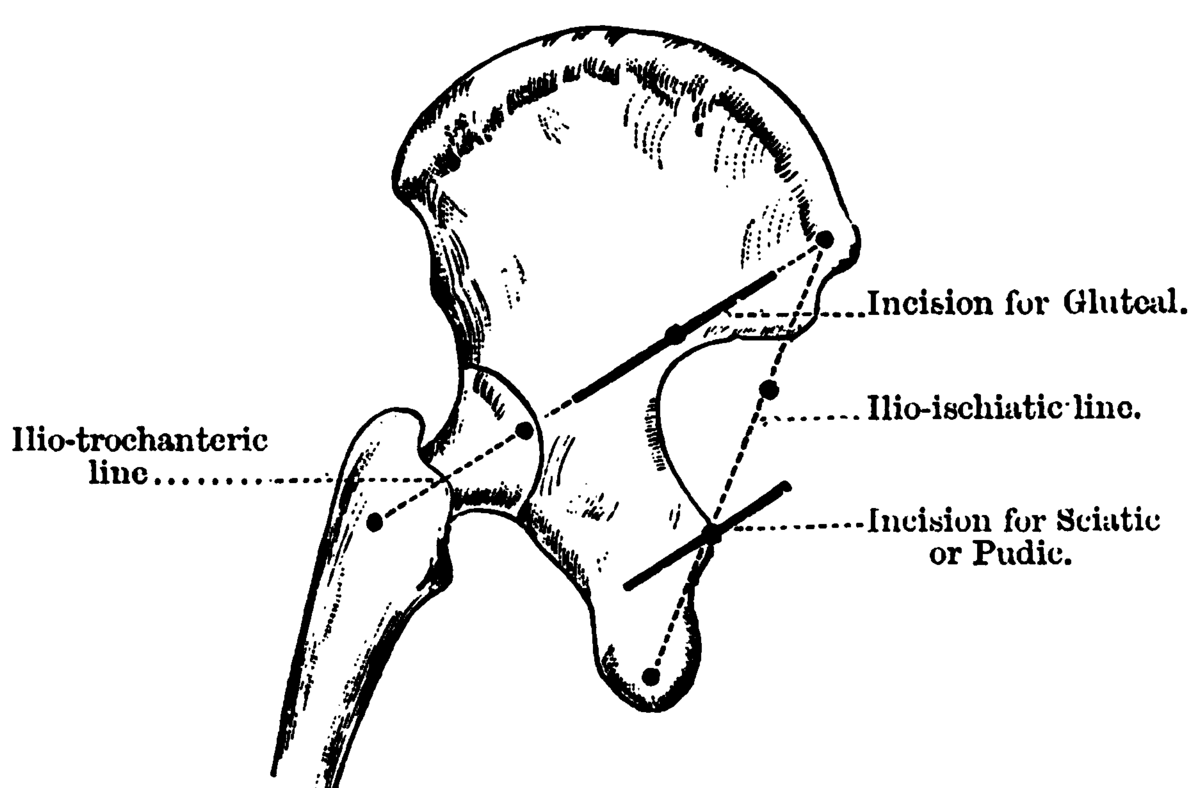
The internal iliac has been tied for aneurism of its branches and for wounds. It was first tied by STEVENS, of Vera Cruz, in 1812, for aneurism of the nates—the woman lived for three years after the operation. He made an incision five inches long, external to and parallel with the deep epigastric artery. Considering the serious nature of the operation, it has been wonderfully successful —probably on account of the free collateral circulation preventing any tendency to gangrene.

The Gluteal, Sciatic, and Pudic Arteries.—These three branches of the internal iliac artery are found in the gluteal region, beneath the gluteus maximus muscle. They all emerge from the pelvis, through the great sacro-sciatic foramen. The trunk of the **Gluteal,** which is about the size of the ulnar artery, at first lies between the lumbo-sacral cord and the first sacral nerve, and then passes into the gluteal region lying between the pyriformis and the gluteus minimus muscles, where it divides into a superficial and a deep division. The *superficial* part is distributed to the under surface of the gluteus maximus; the *deep* divides into superior and inferior branches—the *superior* runs along the middle curved line between the gluteus medius and minimus, and anastomoses with the ascending branch of the external circumflex artery; the *inferior* crosses the gluteus minimus to the great trochanter. The **Sciatic** artery appears below the pyriformis; it is larger than the gluteal artery. It anastomoses with the external and internal circumflex branches of the profunda femoris. Its branches are—(1) Muscular, or inferior gluteal, to gluteus maximus; (2) coccygeal; (3) comes nervi ischiadici; (4) anastomotic. The **Pudic** artery is seen close beside the sciatic—this vessel is found in three regions—(1) In the cavity of the pelvis; (2) in the gluteal region; and (3) in the perineum. It winds out of the great sacro-sciatic foramen, crosses over the spine of the ischium, and re-enters the pelvis by the lesser sacro-sciatic foramen above the tendon of the obturator internus. As it lies on the spine of the ischium it has a vein on each side, the nerve to the obturator internus on its outer side, and the pudic nerve internal to it. It is found in the outer wall of the ischio-rectal fossa, within a sheath of the parietal pelvic fascia, and lies about an inch and a half above the lower border of the tuberosity of the ischium. It is accompanied by two veins and the pudic

nerve, the nerve being at the lower part. The artery is next found between the two layers of the triangular ligament, and finally pierces the anterior layer, half-an-inch from the pubic arch, and ends by dividing into the artery to the corpus cavernosum and the dorsal artery of the penis. Its branches are—(1) Inferior hæmorrhoidal; (2) superficial perineal; (3) transverse perineal; (4) artery to the bulb; (5) artery to the corpus cavernosum; (6) dorsal artery of the penis. It will be noticed that this artery or its branches are involved in many surgical operations, as—operations on the penis, perineal lithotomy, operations about the anus, lower part of rectum, and ischio-rectal fossa.

The position of these three vessels may be indicated on the surface thus:—"If a line is drawn from the posterior superior spinous process of the ilium to the tuberosity of the ischium, the gluteal artery issues from the pelvis at a point about an inch external to the junction of the upper and middle thirds of this line; the ischiatic and pudic arteries a couple of inches lower down" (CHIENE).

Fig. 26.
GUIDE TO ARTERIES OF BUTTOCK.



Another method is to draw a line (*ilio-trochanteric*, which corresponds in direction to the fibres of the gluteus maximus) from the posterior superior iliac spine to the posterior superior angle of the great trochanter. The junction of the upper with

the middle third marks the point of emergence of the gluteal artery from the great sciatic notch. For the sciatic and pudic draw a line *(ilio-ischiatic)* from the same point to the tuberosity of the ischium. The junction of the lower with the middle third marks the point of emergence of the sciatic and pudic arteries from the great sciatic notch (Fig. 26).

The three vessels are simply covered by the integumentary structures and the gluteus maximus, and may be reached for the purpose of ligature by **incisions**, three or four inches long, *in the direction of the fibres of the gluteus maximus*, over the points indicating their respective positions; but in by far the greater number of cases the guide to the artery affected will be the pulsating aneurismal tumour. Of the three, the gluteal is the one most frequently affected. It is the vessel most frequently wounded in this region, from sitting down on something sharp, or, for example, from the accidental collapse of the chamber utensil. Any of the three may be wounded by a punctured wound in this region. In cases of traumatic aneurism, the best treatment to adopt is to perform the "old operation;" failing this, the internal or even the common iliac may be ligatured.

The **Collateral Circulation** (see Fig. 24) is carried on by anastomoses between the gluteal (12) and sciatic (19) arteries with the ascending branch of the external (21) and internal circumflex (26), branches of the profunda femoris; and in the case of the pudic by the anastomoses of its branches with the corresponding branches from the other side.

The **Obturator Artery** runs along the lateral pelvic wall in the extra-peritoneal fat, between the peritoneum and the pelvic fascia to the upper part of the thyroid foramen, and leaves the pelvis by passing *above the upper edge* of the pelvic fascia; the nerve of the same name lies above it, and its vein is below it. It gives off an *iliac*, a *vesical*, and a *pubic* branch. Outside the pelvis it divides into an external and an internal branch that skirt the sides of the thyroid foramen and anastomose with each other, and with branches of the internal circumflex. The *external* branch sends a twig to the hip joint through the cotyloid notch, which ramifies on the round ligament as far as the head of the femur; it is accompanied by a branch of the obturator nerve.

The **Ilio-lumbar Artery.**—The *lumbar* branch of this vessel anastomoses with the last lumbar artery, and the *iliac* with the gluteal, deep circumflex iliac, external circumflex and epigastric arteries.

THE EXTERNAL ILIAC.

Origin.—From the bifurcation of the common iliac at the lumbo-sacral articulation. **Extent.**—From its point of origin to Poupart's ligament. **Course.**—It runs along the brim of the true pelvis, and its course is indicated by the lower two-thirds of a line drawn from a point three-fourths of an inch below, and a little to the left of the umbilicus, to a point midway between the anterior superior iliac spine and the symphysis pubis. The artery, with its accompanying vein, are bound down to the psoas muscle in a common sheath of fascia. **Relations.**—In *front*—(1) The intestines; (2) peritoneum; (3) a process of iliac fascia; (4) spermatic vessels; (5) vas deferens (4 and 5 are more especially at its lower part); (6) genital branch of the genito-crural nerve; (7) the circumflex iliac vein. To its *inner side*—(1) The external iliac vein; (2) the vas deferens. To its *outer side*—the psoas magnus. *Behind* it—(1) The external iliac vein (on the right side); (2) the psoas magnus. On the *left side* the vein is to the inner side of the artery in the whole of its course, but is beneath its upper part on the right side (see Fig. 25); on the *right side* the ureter very often crosses the upper part of the external iliac.

The **patient** is to be placed in the recumbent position, with his shoulders raised by pillows, and his knees semi-flexed, to relax the abdominal muscles. The colon must be well emptied by an enema, the pubes shaved and the bladder emptied before beginning the operation. The **Surgeon** stands on the same side as the vessel about to be tied.

Abernethy's Incision.—Make a curved incision, four or five inches long, with the convexity downwards and outwards, commencing about an inch external to the middle of Poupart's ligament and an equal distance above it, and carry it upwards and outwards parallel with the ligament, ending an inch internal to, and a little above, the anterior superior iliac spine. This form of incision more easily reaches the artery at its upper part away from the seat of disease —supposing it to be tied for femoral aneurism. This incision,

though often called ABERNETHY'S, is not, strictly speaking, the incision he used; he first tied this vessel in 1796, but made his incision in the course of the vessel. ABERNETHY'S incision is said to leave a great tendency to hernia, due to the injury to, and the consequent weakening of, the muscular planes; this tendency may be partially obviated by the careful application of deep sutures. Its chief advantage is, that one may ligature the vessel at any part of its course, or even, if necessary, tie the common iliac, and it is, therefore, to be preferred when operating in cases of spontaneous aneurism. The structures divided and the steps of the operation are the same as in ligature of the common iliac. After the peritoneum is stripped up, the loose cellular tissue sheath surrounding the vessel must be carefully scratched through with the finger nail, aided by a director, or the point of the aneurism needle; when sufficiently cleared pass the needle from within outwards to avoid injury to the vein. The incision must not be carried too far downwards lest the deep epigastric vessels, or the internal abdominal ring and the structures passing through it, be implicated; further, it should not be too near Poupart's ligament, lest the deep circumflex iliac artery be cut. Special care must be taken not to include the genital branch of the genito-crural nerve in the ligature, as this nerve lies on the artery, or wound the peritoneum. In four cases of ligature of this artery, the patients died from *tetanus*, probably from implication of the nerve in question. The chief causes of death after this operation are—(1) Gangrene, especially likely to occur when the deep epigastric is injured; (2) secondary hæmorrhage, especially when the vessel is diseased, or when it is tied too near its origin, or, again, when tied too near Poupart's ligament; and (3) peritonitis. Other dangers of this operation are—injury to the external iliac vein, and ligature of the genito-crural nerve.

Sir Astley Cooper's Incision.—Make a semi-lunar incision extending from an inch internal to the anterior superior iliac spine to half-an-inch external to the external abdominal ring, half-an-inch above Poupart's ligament; the incision should be about three inches in length with its centre over the artery. This incision chiefly exposes the artery at the lower part, and should be made, as nearly as possible, in the direction of the fibres of the external

oblique. This incision divides the superficial epigastric artery, which must be secured at once. Then divide the tendon of the external oblique on a director, and after this lay aside the knife and complete the operation with director and forceps. Scratch through the cremaster muscle and push the cord upwards, and after this tear through the transversalis fascia with the fingers. The wound must now be kept open by two copper spatulæ: the internal one pulls the cord and the deep epigastric artery upwards and inwards, the outer one pulls the internal oblique and transversalis upwards and outwards; both also displace the lower part of the peritoneal sac upwards, as the whole operation should be extra-peritoneal. The vessel is now exposed, and must be cleared at a point an inch above Poupart's ligament to avoid the two large branches; the needle must be passed *from* the vein. As the vessel lies exposed in the wound, the following important relations must be noted—(1) The genito-crural nerve lies on the vessel; (2) the deep circumflex iliac vein is crossing it; and (3) the external iliac vein lies to its inner side. Should this method be adopted in cases of aneurism the vessel is exposed too near the seat of the disease, the deep circumflex iliac artery and vein are in great danger, as well as the vas deferens and spermatic vessels, as the outer end of the inguinal canal is opened up; and should the vessel, when exposed, be found diseased, it is impossible to prolong the incision upwards so as to tie it at a higher point. The chief advantages, when compared with the previous operation, are—(1) That the peritoneum is less disturbed, and (2) there is less tendency to hernia afterwards. COOPER's operation is usually selected when it is found necessary to ligature the external iliac for secondary hæmorrhage after a wound or amputation, and where therefore the coats of the vessel are healthy, and more especially when the abdomen is thin and flat.

PECULIARITIES.—The deep epigastric may arise from any part of the external iliac between Poupart's ligament and two and a half inches above it. Not unfrequently the obturator arises by a common trunk with the deep epigastric.

Branches.—Two branches are given off from this artery just above Poupart's ligament—(1) The deep epigastric, and (2) the deep circumflex iliac.

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The **Deep Epigastric Artery.**—This vessel arises from the external iliac about a quarter or half-an-inch above Poupart's ligament; it then descends to the level of that ligament and curves forwards to reach the anterior aspect of the peritoneal bag, and after this passes upwards and inwards to enter the sheath of the rectus. At first it lies in the fat, between the peritoneum and the fascia transversalis, then piercing this fascia, enters the sheath of the rectus by passing in front of the fold of Douglas.

It has many **important Surgical relations.**—(1) It forms the outer boundary of Hesselbach's triangle; (2) it is directly in the way in ligature of the external iliac artery by Sir Astley Cooper's incision; (3) with the internal mammary it forms a direct communication between the subclavian, intercostals, and external iliac, and is therefore an important medium of collateral circulation in ligature of either of these vessels; (4) it lies close to the inner side of the internal abdominal ring; (5) the spermatic cord in the inguinal canal lies in front of it, only separated from it by the fascia transversalis; (6) the vas deferens hooks round its outer side. Its **branches** are—(*a*) *Cremasteric*, to the cremaster muscle; (*b*) *pubic*, to anastomose with a corresponding branch from the obturator; (*c*) *cutaneous;* and (*d*) *muscular*.

The **Deep Circumflex Iliac Artery.**—Arises from the outer side of the external iliac about the same level as the deep epigastric, and runs outwards behind Poupart's ligament to the anterior superior iliac spine, then along the crest and anastomoses with the ilio-lumbar artery. Like the deep epigastric it at first lies in the extra-peritoneal fat, between the peritoneum and the fascia transversalis; it then pierces this fascia and lies between it and the transversalis muscle, and lastly pierces the muscle and lies between it and the internal oblique. The branch between the internal oblique and the transversalis muscles forms a useful landmark in operations in this region, as in Abernethy's method of securing the external iliac artery. It is also an important collateral supply in ligature of the external iliac. In aneurism of the external iliac there is pain in the lumbar region along the crest of the ilium, in the testicle and scrotum, and down along the front and outer side of the thigh, from pressure on the branches of the lumbar plexus.

Collateral Circulation (see Fig. 24).—1. The deep epigastric branch (9) anastomosing with the terminal branches of the internal mammary (5) and aortic intercostals (2). 2. The deep circumflex iliac branch (20), and the ilio-lumbar branch (11) from the internal iliac, anastomosing with the lower intercostals (2), and lumbar branches of the aorta (6). 3. The gluteal artery (12) from the internal iliac, anastomosing with the external circumflex branch (27) of the profunda femoris. 4. The sciatic artery (19) from the internal iliac, anastomosing with the internal circumflex branch of the profunda (26). 5. The obturator artery (23) from the internal iliac, anastomosing with the internal circumflex branch of the profunda (26).

RÉSUMÉ of ABERNETHY'S method:—

1. Use the curved incision as already explained.
2. Divide the external oblique in the direction of its fibres, with the ilio-hypogastric and the ilio-inguinal nerves.
3. Divide the other two muscles to the full extent of the external incision, and secure the branch of the deep external circumflex.
4. Open the transversalis fascia at the *lower* part of the wound in the same way that the sheath of an artery should be opened, and enlarge on director or tear with fingers, taking care not to injure the peritoneum in any way, especially by tearing a hole in it.
5. Roll the patient over towards the sound side, and use broad copper spatulæ to keep the edges of the wound apart.
6. Note the relation of the vein to the artery: also the genito-crural nerve lying on it, which must be carefully turned aside.
7. Pass over the psoas and not below it, and tear through the thin fascia prolonged from its inner edge over the vessel.
8. Scratch through the loose cellular sheath with the point of the finger and aneurism needle; thread the needle, pass it *from the vein*, and tie.

Beware of too free disturbance of the extra-peritoneal cellular tissue, and use strict antiseptic precautions throughout the operation. With but slight variations this *résumé* is applicable to ligature of the common and internal, as well as to the external iliac.

RÉSUMÉ of COOPER's operation:—

1. Make an incision three inches long with its centre over the vessel, and about half-an-inch above Poupart's ligament.
2. Secure superficial epigastric artery, and divide the tendon of the external oblique, the whole length of the skin wound.
3. Scratch through the cremaster muscle and push the cord upwards and inwards, displacing or dividing the internal oblique and transversalis muscles as far as may be necessary.
4. Now hook the parts well aside by blunt hooks, or retractors, or copper spatulæ—the *inner* one pulls the cord, the internal oblique and the deep epigastric artery upwards and inwards, the *outer* one pulls the internal oblique and transversalis upwards and outwards.
5. Next, with the fingers make an opening in the transversalis fascia over the vessel by tearing it through from Poupart's ligament; this structure may be regarded in the same light as the femoral sheath, and it is therefore unnecessary to divide it the *whole length* of the external wound. Further, when divided in this way the peritoneum is less likely to be injured.
6. Clear the vessel in the usual way at a point about an inch above Poupart's ligament, in order to avoid its two large branches. The needle must be passed *from* the *vein*, which lies on its inner side. Take care of the deep circumflex iliac vein which is seen crossing the artery, and the genito-crural nerve which lies upon the vessel.

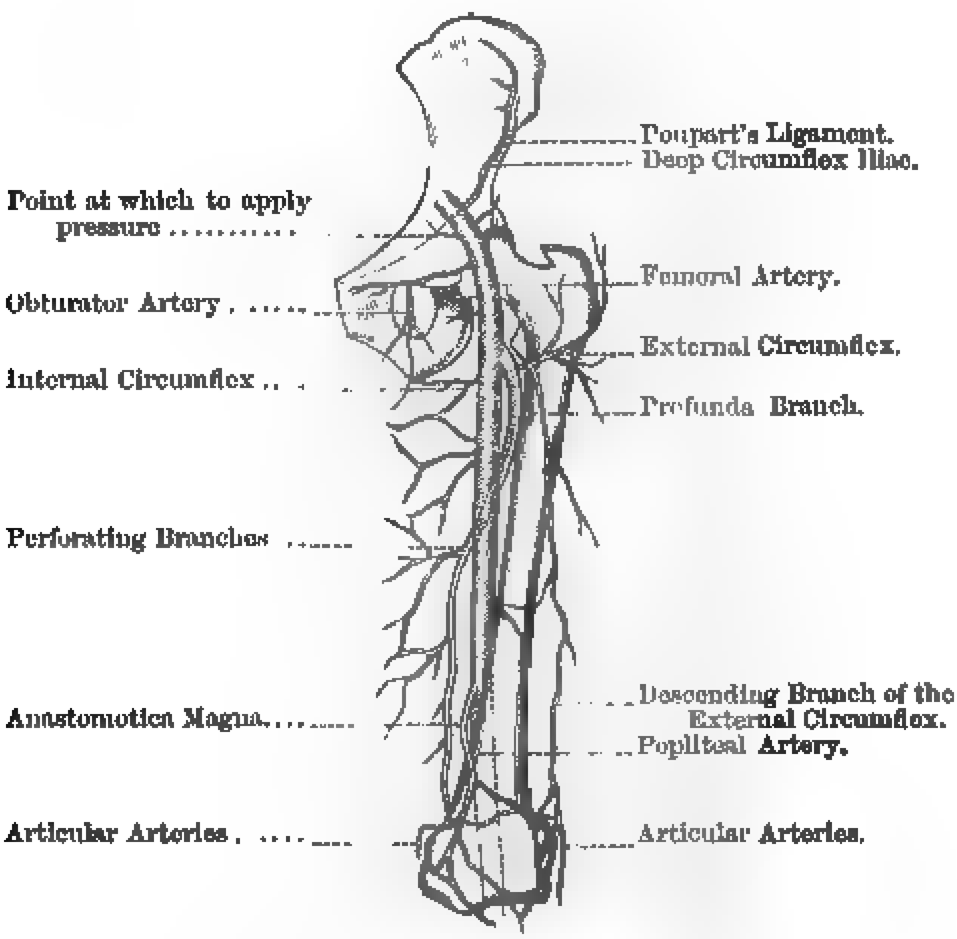
CHAPTER XI.

ARTERIES OF THE LOWER EXTREMITY.

The Femoral Artery.—Origin.—It is the direct continuation of the external iliac artery. **Extent.**—It extends from Poupart's

Fig. 27.

Showing Relation of Artery to Femur.

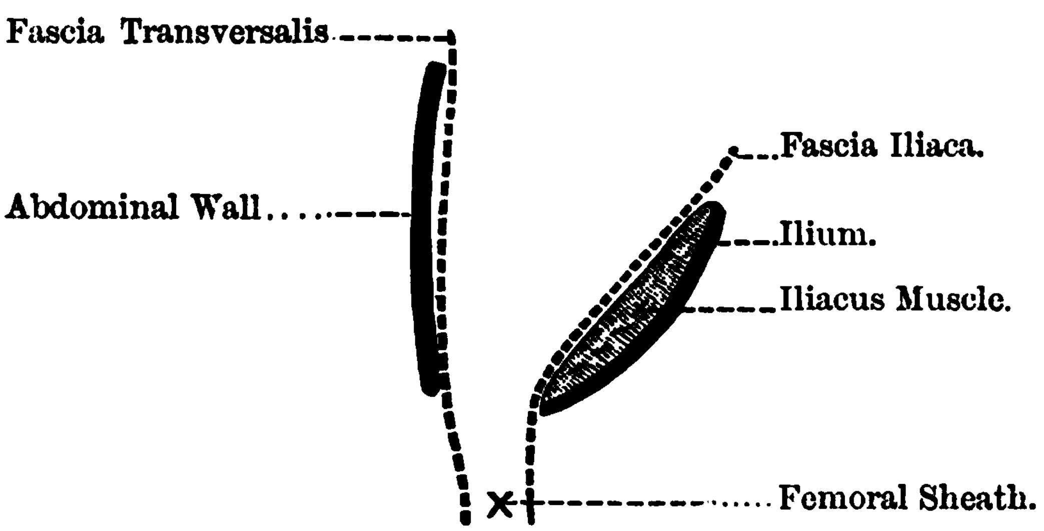


ligament to the opening in the adductor magnus; this corresponds to the upper two thirds of the thigh. **Course.**—Flex the thigh upon the abdomen, and rotate it a little outwards, and the course

is then indicated by a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis, to the inner side of the internal condyle of the femur, or to the "adductor tubercle." The artery at first lies immediately over the head of the femur, but as it passes downwards it takes an oblique course along the inner side of that bone, and finally passes behind it as it enters the popliteal space through the opening in the adductor magnus. In applying pressure, therefore, to the femoral artery in the upper part of its course we ought to press directly backwards against the *body of the pubes*, or the ilio-pectineal eminence (Fig. 27), but, if applied to the middle third of the thigh, as the artery lies in Hunter's canal, the pressure must be directed outwards towards the femur.

Fig. 28.

FORMATION OF THE FEMORAL SHEATH.



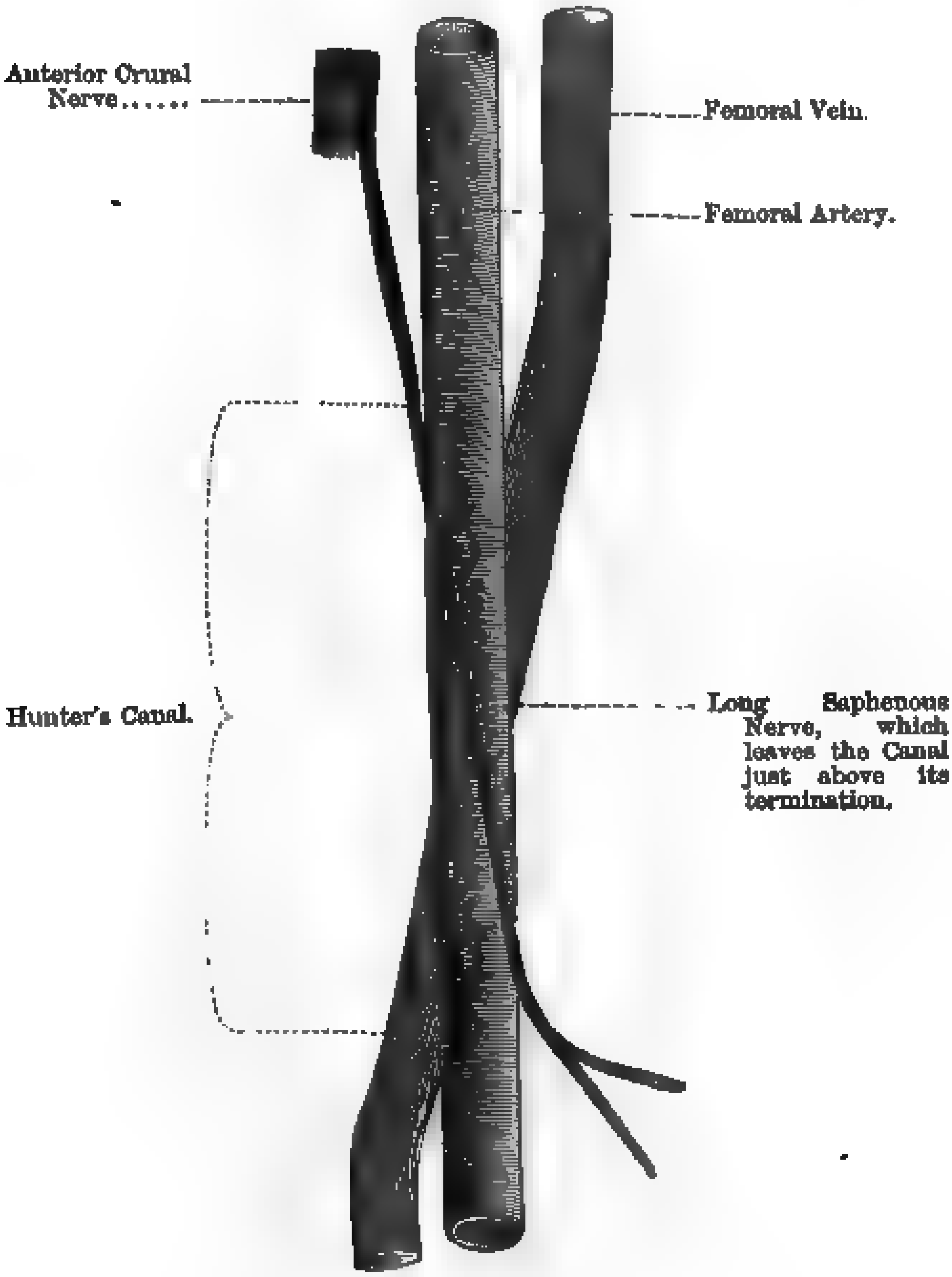
Note that the "*common femoral*" of Surgeons is the femoral artery before it has given off its profunda branch, and is usually about one inch and a half in length; below this point it is known as the "*superficial femoral.*" But the *common femoral* and the *superficial femoral* of Surgeons form simply the femoral of Anatomists; while the "*deep femoral*" of Surgeons, is the *profunda* branch of Anatomists.

Relations.—The artery is divided into a superficial and a deep part. The **superficial part** is contained in Scarpa's triangle, and corresponds, in extent, with upper third of the thigh; the **deep part** is contained in Hunter's canal, and corresponds with the middle third of the thigh. In *front* of the artery, as it lies in Scarpa's

triangle, we have—(1) Skin; (2) superficial fascia; (3) deep fascia; (4) cribriform fascia; (5) some large tributaries of the long saphenous vein; (6) the anterior part of femoral sheath; (7) the internal

Fig. 29.

FEMORAL ARTERY AND VEIN.



cutaneous nerve, just at the apex of the space. The crural branch of the genito-crural is found in the sheath, lying in front of the femoral artery; it leaves the sheath by piercing its outer border.

As it lies in Hunter's canal, in addition to the superficial structures, we find covering it—(8) the sartorius muscle; (9) roof of Hunter's canal; and (10) the long saphenous nerve. *Behind* it we find—(1) The psoas muscle, which separates it from the margin of the pelvis and the capsule of the hip-joint; (2) the nerve to the pectineus; (3) the femoral vein; (4) the pectineus; (5) the adductor longus; and (6) part of the adductor magnus. On the *inner side*—(1) The femoral vein (at the upper part); (2) the adductor longus; and (3) the sartorius. On the *outer side*—(1) The anterior crural nerve, which lies about a quarter of an inch from the vessel, a few fibres of the psoas muscle intervening; (2) the vastus internus; (3) the femoral vein (at the lower part); (4) the internal cutaneous nerve; (5) the long saphenous nerve; (6) the nerve to the vastus internus. The femoral vein (Fig. 29) is at first on the same plane, and on the inner side of and close to the artery; but in its course downwards it gradually passes behind the artery, until, when it reaches the apex of Scarpa's triangle, it lies directly behind it; it then gradually passes to its outer side. The following is the arrangement of vessels from before backwards, at the apex of Scarpa's triangle—(1) Femoral artery; (2) femoral vein; (3) profunda vein; and (4) profunda artery; hence, if a person receives a stab or bullet wound at this point, these vessels are liable to be injured. The adductor longus muscle separates the femoral vessels from the profunda vessels in this region. The femoral artery may be tied —(1) above the origin of the profunda, *i.e.*, the common femoral; (2) the superficial femoral at the apex of Scarpa's triangle; and (3) the superficial femoral in Hunter's canal.

The Common Femoral.—Ligature of this part of the vessel has been anything but a successful operation. There are various reasons for this—(1) It is a short trunk, the usual length being about an inch and a half, and it may be much shorter. (2) The large number of branches given off in the neighbourhood, so that it is almost impossible for a satisfactory clot to form. These branches are—(*a*) The deep epigastric and deep circumflex iliac, just above its origin; (*b*) the profunda, one to two inches below; (*c*) occasionally also one of the circumflex arteries, usually the internal; (*d*) three or four small branches—superficial epigastric, superficial circumflex iliac, superficial external pudic, and deep

external pudic. It may be said that these vessels are so small that they are not worth taking into account, but this is by no means the case; they bleed very freely and more especially if they are cut near their origin, for then the cut end retracts so much that the wound becomes, for all practical purposes, equivalent to a wound of the common femoral itself. (3) Another possible objection to this operation is lest the cicatrix, by its contraction, may interfere with the integrity of the femoral ring. Another fact very much against the success of this operation is, that the artery is of so uncertain length. The common femoral is sometimes wounded in shoemakers when, in paring leather, the knife slips off the lap-board.

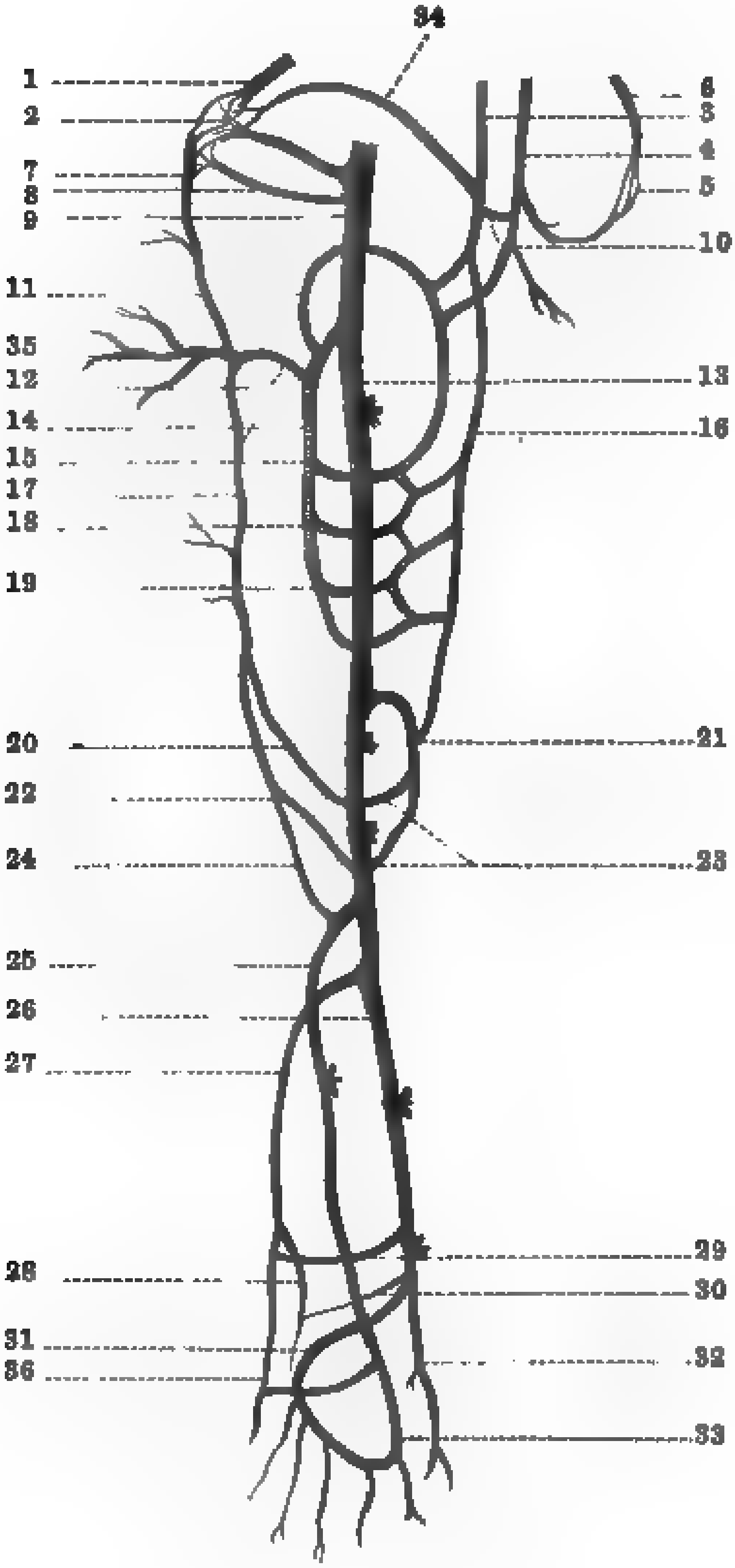
The vessel may be reached either by—(1) A **Vertical incision,** two inches long, right over the artery, beginning at Poupart's ligament; or by (2) a **Transverse incision** (PORTER'S), two and a half inches long, across the course of the vessel, about an inch below Poupart's ligament. The vertical incision is probably the best. The **Surgeon** stands on the outer side of the limb, on both sides of the body. In either case the **Structures cut through** are—(1) Skin; (2) superficial fascia with the superficial vessels, nerves, and lymphatics in this region; (3) iliac part of the deep fascia and branches of the genito-crural, and anterior crural nerves; (4) the femoral sheath, which must be opened over the vessel. Carefully isolate the artery from the surrounding structures and pass the needle from the inner side, *i.e.*, *from* the vein, taking special care not to include the crural branch of the genito-crural nerve, which lies on the sheath of the artery. As already mentioned, the results of this operation are by no means satisfactory—(1) Gangrene has followed in several cases; but the great cause of death is (2) secondary hæmorrhage. Hence, in cases where it might be deemed expedient to tie the vessel at this point, it is better not to do so, but rather to ligature the external iliac at once.

Collateral Circulation (Fig. 30).—1. Sciatic (3), from the internal iliac, anastomosing with the internal circumflex (11), external circumflex (35), and perforating arteries (15, 18, 19). 2. The obturator (4) from the internal iliac, with the internal circumflex of the profunda (11). 3. The gluteal (1) from the internal iliac, with the ascending branch of the external circumflex of the profunda (7). 4. The deep external pudic with the superficial peroneal artery.

Fig. 30.

COLLATERAL CIRCULATION OF THE LOWER EXTREMITY.

(After SMITH and WALSHAM.)



Explanation of Fig. 30.

1. Gluteal artery.
2. Anastomoses between the gluteal, sciatic, external circumflex, deep circumflex iliac, and superficial circumflex iliac arteries.
3. Sciatic artery.
4. Obturator artery.
5. Anastomosis between the pubic branches of deep epigastric and obturator arteries.
6. Pubic branch of deep epigastric.
7. Ascending branch of external circumflex.
8. Superficial circumflex iliac.
9. Common femoral.
10. Anastomosis between obturator and sciatic arteries.
11. Internal circumflex artery.
12. External circumflex artery.
13. Superficial femoral.
14. Deep femoral *(profunda)*.
15. First perforating.
16. Comes nervi ischiadici.
17. Descending branch of external circumflex.
18. Second perforating.
19. Third perforating.
20. Superior external articular.
21. Anastomotica magna.
22. Inferior external articular.
23. Superior and inferior internal articular arteries.
24. Anterior tibial recurrent.
25. Anterior tibial.
26. Posterior tibial.
27. Peroneal.
28. Anterior peroneal.
29. Communicating branch between the peroneal and posterior tibial.
30. Malleolar branches.
31. External plantar artery.
32. Internal plantar artery.
33. Dorsalis pedis.
34. Branch of sciatic artery.
35. Transverse branch of the external circumflex.
36. Anastomosis behind external malleolus.

Ligature at the Apex of Scarpa's Triangle.—The safest place at which to apply a ligature is about five inches from Poupart's ligament; this point has, therefore, been called the "seat of election." This is usually well out of the way of the profunda, as this vessel has not been known to take origin lower down than four inches from the origin of the femoral. The femoral artery has been tied by CARNOCHAN as a means of curing Elephantiasis Arabum.

THE OPERATION.

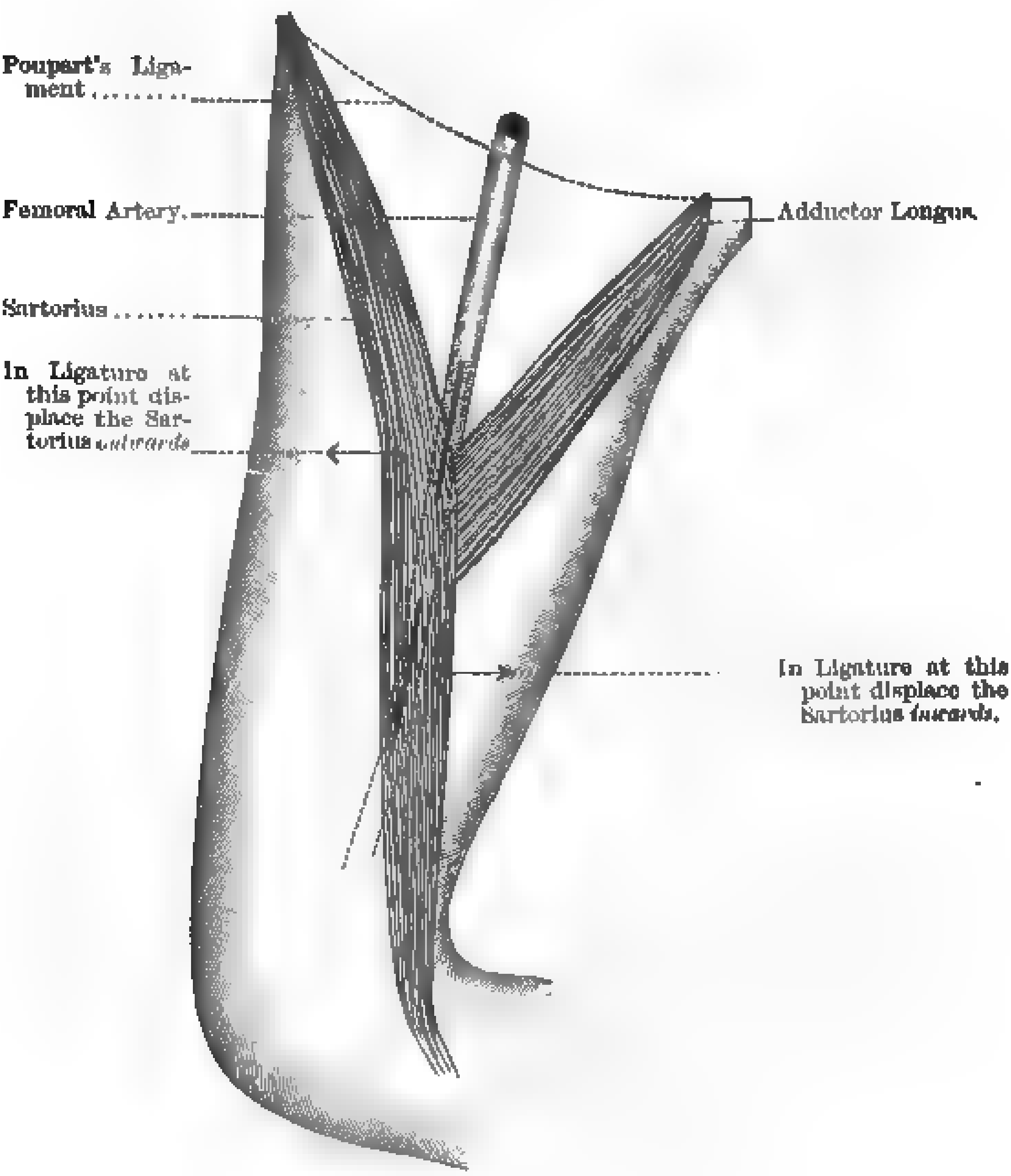
Position of the Patient.—He should be recumbent, his thigh abducted, flexed, and rotated outwards, with the knee bent and resting against a pillow. The **Surgeon** stands on the outer side of the limb, on both sides of the body.

Incision.—Ascertain the position of any large superficial vein, by making pressure on the upper part of the saphena vein; stretch, but do not displace, the skin with the left hand; and then make an incision three or four inches long in the course of the vessel, its centre corresponding to the point at which the artery is to be tied, which must be at least five inches below Poupart's ligament, in order to be well away from the origin of the profunda (Fig. 31). This incision is *not* parallel with the inner edge of the sartorius, but will cross that muscle obliquely, and it must not be made too far inwards lest the long saphenous vein be wounded, or the adductor longus be exposed instead of the sartorius. The adductor longus will be recognised by the direction of its fibres—passing downwards and outwards, whereas the fibres of the sartorius pass downwards and inwards. We **cut through**—(1) The skin; (2) superficial fascia and fatty tissue; (3) the deep fascia forming the sheath of the sartorius, which at this point crosses the artery obliquely. An **assistant** with blunt hooks now keeps the edges of the wound in the fascia apart, and the Surgeon, with scalpel and forceps, proceeds to define the inner edge of the sartorius, which is then to be gently drawn towards the *outer* side, and held there by a broad copper spatula. (4) Clear away any loose cellular tissue and expose the femoral sheath, and next make a small opening in it. The side of the opening furthest from the operator is then to be secured by a pair of toothed forceps and given to an assistant. This prevents the possibility of losing the opening. After this open (5) the proper

sheath of the vessel, which is then cleared and ligatured in the usual way. At the point where the artery is ligatured the vein lies behind it, so that it matters little from which side the needle

Fig. 31.

Incisions for Ligature of Femoral.



is passed; but on account of this relation, great care is necessary in clearing the artery and passing the needle; and not only does the vein lie immediately behind the artery, but it is more firmly

adherent to it than is the case with most large arteries and their companion veins, so that the artery must be completely cleared before we attempt to pass the ligature, which must then be passed without using force. The vein is often rather to the inner side at this point, so that, on the whole, it might be as well to pass the needle from the *inner* side. Some Surgeons advise that it should be passed unarmed, and then threaded and withdrawn, as, they say, there is less risk of wounding the femoral vein by so doing. But, while the artery should be cleared completely, due care must be taken at the same time to avoid undue disturbance of the parts, lest the "*vasa vasorum*," supplying the coats of the artery, be unnecessarily injured, and lead to death of that part of the vessel. The crural branch of the genito-crural, the internal cutaneous and long saphenous nerves must all be carefully avoided, as they often lie in front of the vessel.

This is a very successful operation. The more important untoward accidents are—(1) Gangrene; (2) wound of the vein; and (3) secondary hæmorrhage. (For the Preventive Treatment of Gangrene, see page 33).

1. **Gangrene** is especially apt to follow if the vein be injured. The best way to avoid this is to clean a *small* part of the vessel thoroughly with *scalpel and dissecting forceps* (BELL). No blunt instruments, such as directors, etc., are admissible. If gangrene occurs, amputate through the lower third of the thigh (SPENCE).

2. **Wound of the Vein** is very frequently fatal from septic phlebitis or gangrene. Should this accident occur, the ligature should be withdrawn, and a new opening made in the sheath half-an-inch higher up, and the ligature reapplied there, the hole in the vein being tied longitudinally, as complete obliteration of the vein is almost certain to be followed by gangrene.

3. In **Secondary Hæmorrhage** there are various courses open—(*a*) The graduated compress; (*b*) ligature of the external iliac or superficial femoral—this is usually followed by gangrene; (*c*) tie the bleeding point—usually the distal side; and (*d*) if everything else fail, amputate.

For varicose aneurism in this region perform the "old operation," as ligature of the external iliac is very fatal from gangrene, secondary hæmorrhage, and pneumonia.

RÉSUMÉ of the operation at the "seat of election":—

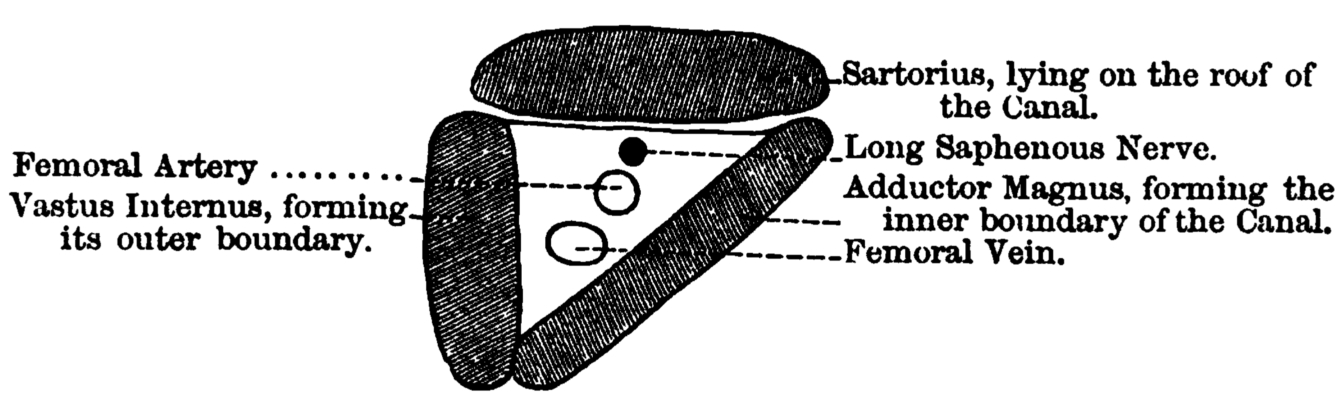
1. Make an incision three inches long in the line of the vessel, with its centre five inches from Poupart's ligament, avoiding the trunk of the long saphena vein, and securing large tributaries.
2. Expose the edge of the sartorius and turn it *outwards.*
3. Turn aside the internal cutaneous and the long saphenous nerves, and the nerve to the vastus internus, and open the sheath common to artery and vein.
4. Then open the sheath proper to the artery, and clean well till the white external coat is seen.
5. Pass the needle unarmed from within outwards, thread, and withdraw.
6. Do not dip the point of the needle too much, but keep it close to the artery, so as to avoid wounding the vein.

LIGATURE IN HUNTER'S CANAL.

This operation is rarely performed now-a-days, as the vessel is too deeply placed, and besides, ligature at the apex of Scarpa's triangle gives better results. "*Hunter's canal*" is formed by an aponeurotic expansion thrown across from the adductors longus and magnus on the inner side to the vastus internus on the outer side.

Fig. 32.

SECTION THROUGH HUNTER'S CANAL, RIGHT SIDE.



(Fig. 32). It is triangular in shape, the base being formed by the expansion already alluded to, and it extends from the apex of Scarpa's triangle to the opening in the adductor magnus, and corresponds, therefore, with the middle third of the thigh. It encloses the femoral artery and vein, and the long saphenous nerve

—the vein being at first behind, and then to the outer side of the artery, while the nerve is above it, and crosses from its outer to its inner side (see Fig. 29). The position of the patient and of the Surgeon is the same as in the previous operation.

Incision.—An incision, three or four inches long, should be made, a finger's-breadth internal to, and parallel with, the line that indicates the course of the artery, so as to cut down on the outer border of the sartorius, and at the same time avoiding the internal saphenous vein (Beck), as, it is said, we may miss the sartorius altogether, and strike the vastus internus instead, if the incision be made too far to the outer side. The vastus will be recognised by its fibres passing downwards and outwards. I am not so sure of this. I think it will be found, as a rule, more convenient and sure to cut in the line that indicates the course of the vessel, as in the previous operation, exposing the sartorius and turning it to the inner side (Fig. 31). **Structures cut through**—(1) Skin; (2) superficial fascia and fatty tissue; (3) through the fascia forming the sheath of the sartorius, and expose the outer edge of that muscle, and draw it well to the inner side. Next divide (4) the roof of Hunter's canal with the point of the knife, and then enlarge the opening with a probe-pointed bistoury; the saphenous nerve is then to be drawn aside, and the proper sheath of the vessel opened, and the artery cleared to the requisite extent, and the ligature passed from the outer to the inner side, and, if possible, about an inch above the origin of the anastomotica magna.

PECULIARITIES.—1. In four cases a double superficial femoral has been found, the two divisions reuniting again near the opening in the adductor magnus to form a single popliteal. 2. The femoral has been found situated at the back of the thigh, passing through the great sacro-sciatic foramen. 3. Sometimes the common femoral is very short, or altogether absent.

Branches of the Femoral.—(1) The superficial epigastric; (2) the superficial circumflex iliac; (3) the superior external pudic; (4) the inferior external pudic; (5) the profunda branch—and (6) the anastomotica magna, which is given off in the lower part of Hunter's canal: it arises just before the femoral passes through the opening. It divides into a *superficial* and *deep* branch—the *superficial* accompanies the long saphenous nerve, while the *deep*

descends in the substance of the vastus internus, in front of the tendon of the adductor magnus, to the inner condyle of the femur, and anastomoses with the superior internal articular, and recurrent of the anterior tibial.

RÉSUMÉ of the operation in " Hunter's canal ":—

1. It is probably better to make the incision in the line of the artery, as we can thus more easily reach the outer edge of the sartorius and avoid the long saphena vein.
2. Open the fascia and expose the outer edge of the sartorius, and displace the muscle *inwards.*
3. Open the roof of the canal, after the manner of the sheath of an artery, and enlarge on a director, or with finger and probe-pointed bistoury.
4. Avoid the internal saphenous nerve and clear the artery as in the higher operation.
5. Clear the artery and pass the needle from the outer side, about one inch above the anastomotica magna.

The only other branch which requires special notice is the profunda branch.

The Profunda Artery *(Deep Femoral).*—This branch arises from the outer and posterior part of the femoral artery about an inch and a half from its commencement. At first it passes downwards and outwards, then curves inwards behind the femoral artery and the adductor longus muscle (this muscle separating the two vessels), and then passes downwards, at first lying between the adductors longus and brevis, and afterwards between the adductors longus and magnus, and terminates by piercing this latter muscle. **Relations.**—It *lies on*—(1) The iliacus, (2) the pectineus, (3) the adductor brevis, and (4) the adductor magnus. In *front* of it (besides the structures covering the femoral artery) we have—(1) The femoral and profunda veins, and (2) the adductor longus. To its *outer side* is the vastus internus. It may be ligatured near its origin by the same incision as that used for ligature of the femoral in the lower part of Scarpa's triangle; or, lower down, by following it inwards behind the adductor longus muscle, but great care would be necessary on account of its relations to its own vein, and also to the femoral vessels.

Branches of the Profunda.—1. The external circumflex—this branch passes outwards beneath the sartorius and rectus, and divides into—(*a*) Ascending branches which pass upwards and anastomose with the gluteal and the circumflex iliac arteries; (*b*) transverse branches which pass outwards over the crureus, and anastomose on the back of the thigh with the internal circumflex, gluteal, sciatic, and superior perforating arteries; (*c*) descending branches which pass downwards towards the knee, and anastomose with the superior articular branches of the popliteal artery. 2. The internal circumflex—this vessel passes directly backwards towards the gluteal region, and there anastomoses with the gluteal, sciatic, and superior perforating arteries. It gives a small branch to the hip joint. It arises from the posterior surface of the profunda, and disappears by passing between the pectineus and psoas muscles; and, continuing its course backwards, between the obturator externus and the adductor brevis, and finally appearing behind between the adductor magnus and the quadratus femoris muscles. On reaching the obturator externus it divides into two branches, one passing above and the other below the adductor brevis; the branch passing beneath appears in the buttock, after giving a branch to the hip joint. 3. The three perforating arteries, which pass backwards *close* to the femur, and appear on the posterior surface of the adductor magnus. These arteries form a regular chain of anastomoses in the back of the thigh, connected above with the gluteal and sciatic arteries, and below with the anastomotica magna and the superior articular branches of the popliteal. The position of the various branches should be kept in mind, as they are apt to be wounded in stabs and other injuries of various parts of the thigh, especially the circumflex vessels.

PECULIARITIES.—It arises sometimes from the inner side of the femoral. It usually arises from one to two inches from the beginning of the femoral. In a few cases it was less than an inch; more rarely it may arise just under Poupart's ligament, and in one case it came from the external iliac. It has been known to arise four inches below the origin of the common femoral.

Collateral Circulation (see Fig. 30).—(*a*) **In ligature of the Superficial Femoral**—1. The descending branches of the external circumflex above (17), anastomosing with the superior articular

branches of the popliteal (20), and anastomotica magna below (21). 2. The obturator artery above (4), anastomosing with the internal circumflex artery (11), muscular branches, and anastomotica magna below (21). 3. The chain of anastomoses already mentioned, formed by the perforating arteries, inosculating above with the gluteal (1), sciatic (34), and ascending (7) and transverse branches of the external circumflex (35), and below with the anastomotica magna (21) and articular arteries (23, 20, 22). 4. The terminal branches of the profunda and sciatic arteries above, anastomosing with the anastomotica magna below (21). (*b*) **In ligature of the Deep Femoral**—1. The descending branches of the external circumflex above (17), anastomosing with the anastomotica magna (21) and the superior articular arteries below (20, 23). 2. Branches of the internal circumflex above (11), anastomosing with the perforating arteries below (15, 18, 19).

POPLITEAL ARTERY.

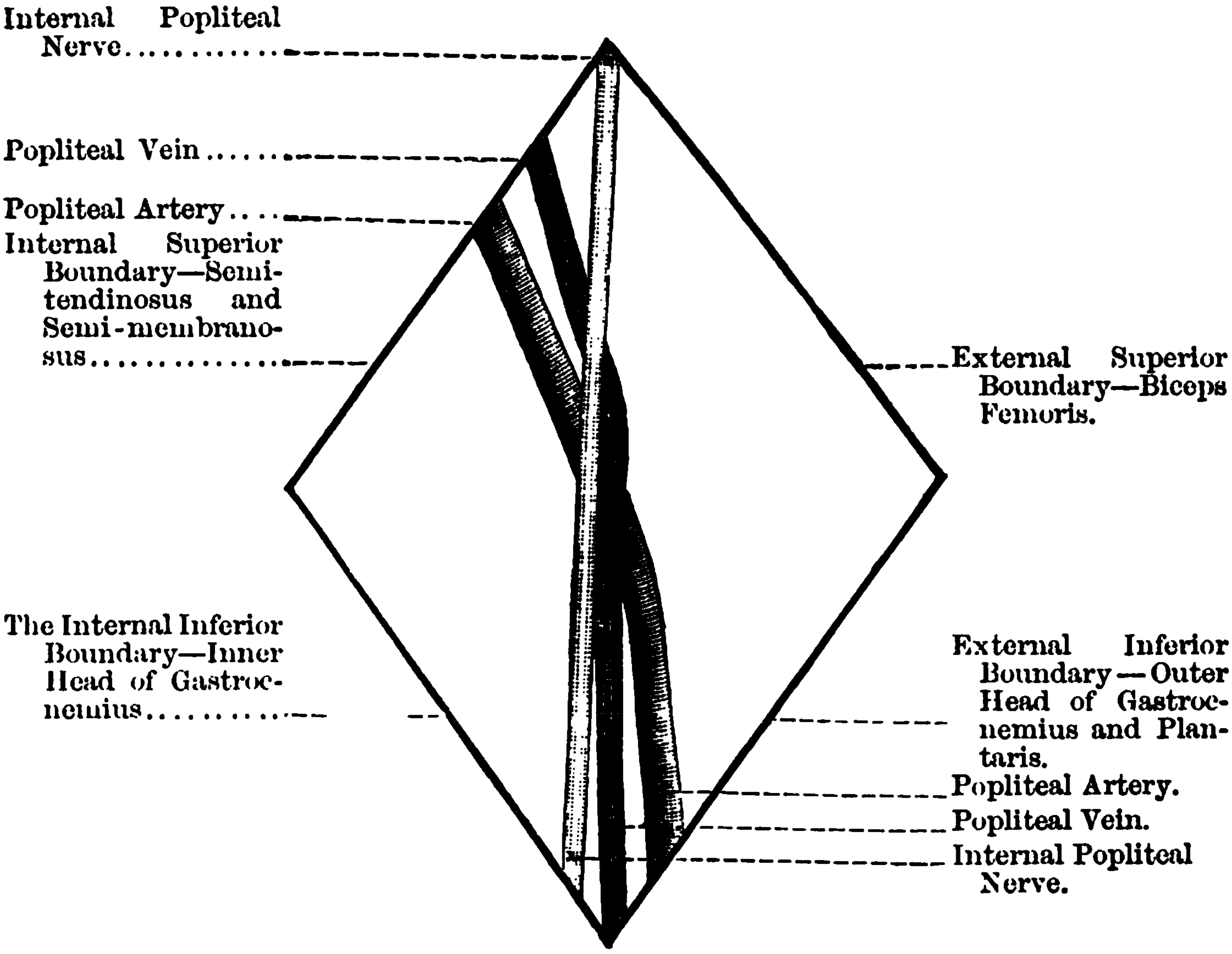
Origin.—It is the direct continuation of the femoral. **Extent.**—It extends from the opening in the adductor magnus to the lower border of the popliteus muscle, where it divides into the anterior and posterior tibials. Its point of division corresponds to the lower part of the tubercle of the tibia in front. **Course.**—It passes obliquely from the inner side of the femur to the middle of the popliteal space, exactly behind the knee joint, and then passes straight downwards. The artery lies deeply in the space, and is covered and crossed by the internal popliteal nerve and the popliteal vein; both vein and nerve crossing the artery from without inwards (Fig. 33). Behind the knee joint, the artery lies in the middle of the space, and is covered (as looked at from behind) by the nerve and vein, so that if a person receive a stab in this region all the three structures may be injured, or perhaps divided, in the order of nerve, vein, artery. **Relations.**—In *front*, the trigone of the femur, the posterior ligament of the knee joint, and the popliteus muscle covered by its fascia. On the *inner side*, semi-membranosus, internal condyle, and inner head of gastrocnemius: to the *outer side*, biceps, outer condyle, outer head of gastrocnemius and plantaris. *Behind*, popliteal vein, the internal popliteal nerve, and the popliteal fascia, with fat, etc. Its branches

are—(1) Superior muscular, (2) inferior muscular or sural, and (3) the five articular—two superior, two inferior, and an azygos.

Ligature of this artery is seldom performed, but it may be rendered necessary for wound, for ruptured artery, or for suppuration of an aneurismal sac in this position. Since the artery bifurcates on a level with the tubercle of the tibia, it is possible to wound the artery *from the front* by a stab, as in a case of accidental wound of the vessel recorded by the late Professor SPENCE.

Fig. 33.

RIGHT POPLITEAL SPACE, FROM BEHIND.



It may be exposed by—(1) a **median incision** either over the centre of the space or over its lower angle, where it lies between the two heads of the gastrocnemius; (2) by an incision on the **inner side above** (JOBERT); (3) by an incision on the **inner side below** (MARSHALL). All the incisions should be about four inches long.

1. **Median Incision.**—The **patient** should be laid on his face, and the **Surgeon** stands on the outer side and makes an incision

in the middle line four inches long, carefully avoiding the external saphenous vein, which empties itself into the popliteal vein at the lower angle of the space. We **cut through** the skin, superficial fascia, cutaneous vessels and nerves; displace the external saphena vein as it lies in the subcutaneous tissue, and then divide the deep, or popliteal, fascia. The limb must now be flexed, and the tendons, with the internal popliteal nerve, carefully held aside with copper spatulæ. Then, by dissecting carefully down amongst the fatty tissue with the handle of the knife, the operator next exposes the popliteal artery and vein, firmly bound together; the vessels must then be separated and the vein displaced to the side most convenient, and when the artery is cleared the needle must be passed from that side. The vein and the artery are very adherent, so that it is a very difficult proceeding to separate them and clear the artery for the ligature. The walls of the vein are said to be specially thick, resembling very closely, in fact, the coats of an artery. This may possibly account for the rarity with which this vein is ruptured. The **Circulation** will be re-established by the superior articular anastomosing with the inferior articular, and other branches around the knee joint.

2. To reach the vessel in its upper third by an **incision** from the **inner side.** The limb is to be placed in the same **position** as in ligature of the femoral. The **guide** is the posterior edge of the tendon of the adductor magnus, which is attached to the "adductor tubercle," or the outer border of the semi-membranosus which overlaps the artery. An incision, three or four inches long, is made parallel with this tendon, beginning at the junction of the middle with the posterior third of the thigh, avoiding, if possible, the long saphenous vein. After dividing the superficial structures and deep fascia, the tendons of the sartorius and internal hamstrings come into view, and must be displaced backwards by a copper spatula. Then, with the left index finger, feel for the tendon of the adductor magnus, and after this dissect carefully through the loose fatty tissue with the handle of the scalpel, or a director, till the artery is exposed. It is next to be cleared sufficiently, and the needle passed from the outer side to avoid the popliteal vein, and the internal popliteal nerve, which lie on that side of the artery in this position (see Fig. 33).

3. It may be ligatured in the **lower third** of its course by MARSHALL'S plan, as it lies on the popliteus muscle, and covered by the gastrocnemius. An **incision**, three or four inches long, is made a little behind and parallel with the inner border of the tibia, avoiding the long saphenous vein. By cutting through the superficial structures and deep fascia, and displacing the inner head of the gastrocnemius backwards, the vessel may be reached and ligatured. The relation of the popliteal vein and internal popliteal nerve, both of which by this time lie rather on the inner side of the vessel (see Fig. 33), will complicate the operation considerably. This, however, matters little, as the operation is of no practical utility.

Popliteal Aneurism.—Next to the thoracic aorta, the popliteal artery is the most common seat of aneurism; this arises from many causes—(1) The amount of violent movement, either of flexion or extension, to which it is subjected, and which is specially apt to injure the two inner coats of the vessel; (2) its feeble lateral support from the fatty tissue in the space; (3) its very frequent acutely bent position, so that the blood impinges with considerable force against the anterior or popliteal surface of the vessel. So great is the force that the whole leg is tilted forwards, unless it is otherwise fixed, as we see how the toe is tilted forwards at each beat of the heart, when one knee is crossed over the other. The usual history is—a feeling of something giving way during exertion, followed by slight lameness, "rheumatic pains" in the limb, coldness, and probably œdema of the foot, numbing pains in the calf and down the limb, and pain in the foot from pressure on the internal popliteal nerve. These symptoms are due to pressure on the popliteal vein and the internal popliteal nerve. The aneurism may either become diffused into the space, leading to gangrene of the limb, or burst into the knee joint. It must be **diagnosed from** —(1) Rheumatism, and (2) from rupture of some of the fibres of the gastrocnemius. It is **treated** by flexion of the limb and compression of the femoral. If this is insufficient, then ligature the femoral.

POSTERIOR TIBIAL ARTERY.

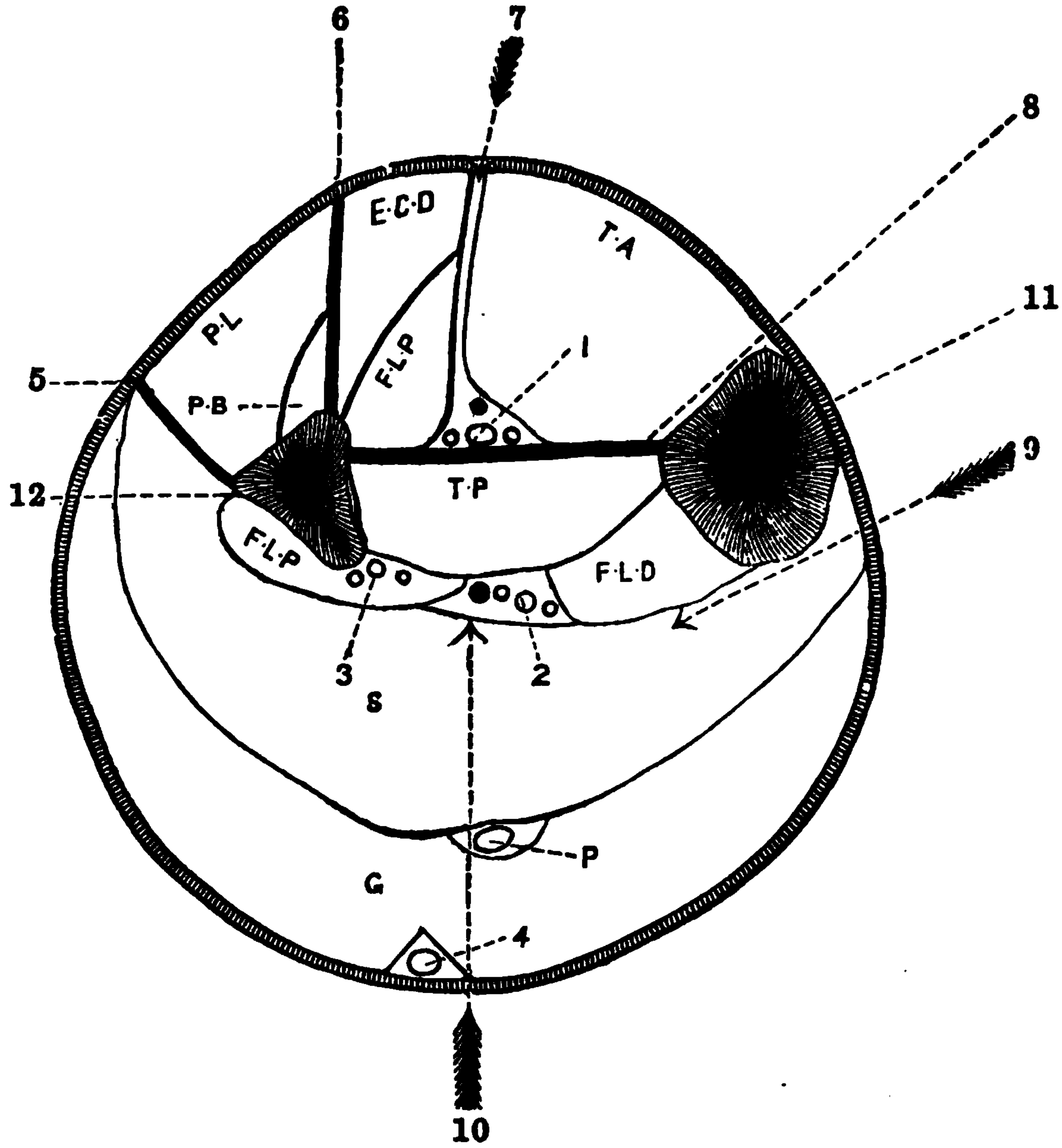
Origin.—From the bifurcation of the popliteal artery, at the *lower border of the* popliteus muscle. **Extent.**—From its point of

origin to the inner side of the os calcis, where it ends by dividing into the internal and the external plantar arteries, beneath the internal annular ligament, about half-an-inch behind and below the internal malleolus, which corresponds to the edge of the abductor hallucis. It lies between the superficial and the deep layers of muscles on the back of the leg (Fig. 34). **Course.**—Its course is indicated by a line drawn from a point one inch below the middle of the popliteal space, and in the middle line of the limb, to a point a finger's breadth behind the internal malleolus. **Relations.**—It is *covered by*—(1) Skin and fascia; (2) gastrocnemius; (3) soleus; (4) plantaris; (5) a tendinous arch covering it, which stretches between the flexor longus digitorum and the flexor longus hallucis; (6) posterior tibial nerve which crosses it at its upper part from within outwards. It *lies upon*—(1) The tibialis posticus; (2) the flexor longus digitorum; (3) the lower end of the tibia (this is of importance in compression). On its *inner side*—The posterior tibial nerve (in its upper third). On its *outer side*—The posterior tibial nerve (in its lower two thirds). It may be ligatured—(1) In the middle third of the leg, or (2) behind the internal malleolus.

1. **In the Middle Third of the Leg.**—The vessel may be reached by two incisions—(*a*) The **Lateral Incision** (see Fig. 34, *9*).—An incision, about four inches long, is made parallel with the inner border of the tibia and fully half-an-inch behind it, avoiding the internal saphena vein. The **patient** is placed in the recumbent position, his knee is to be flexed, his foot fully extended, and the limb laid on its outer side, resting against a pillow; the **Surgeon** stands on the outer side of the limb. By this incision we first **divide** skin and superficial fascia and fatty tissue; the deep fascia is next opened, and the internal edge of the inner head of the gastrocnemius exposed, which must be displaced backwards by a broad copper spatula. The tibial origin of the soleus is now seen, and is to be divided along the whole length of the external incision, about half-an-inch from its attachment to the tibia. In dividing it, the edge of the knife must be turned towards the tibia, and at first only cut through its muscular fibres, exposing its deep tendon. When this is thoroughly exposed, make an opening in it after the manner of opening the sheath of an artery, and complete its division

Fig. 34.

SECTION THROUGH THE CALF.



1. Anterior tibial vessels and nerves.
2. Posterior tibial vessels and nerves.
3. Peroneal vessels.
4. Short saphenous vein.
5. Septum between peronei and posterior muscles.
6. Strong septum between peronei and anterior group of muscles.
7. Weak septum in anterior group, through which the anterior tibial artery is reached.
8. Interosseous membrane.
9. To show position of lateral incision.
10. To show position of direct incision (GUTHRIE'S).
11. Tibia.
12. Fibula.

The names of the muscles are indicated by their initial letters.

NOTE.—In the Anterior group of Muscles, instead of F.L.P., read E.P.P.—Extensor Proprius Pollicis *vel* Hallucis.

on a director, or by a probe-pointed bistoury. The divided soleus is next hooked aside, along with the gastrocnemius, and the space where the artery lies then comes into view. At this point it is accompanied with its venæ comites, and at the upper part of the incision the posterior tibial nerve lies internal to it, then over it, and lastly, at the lower part of the wound, to its outer side. These structures rest on the fascia, covering the deep muscles (tibialis posticus and flexor longus digitorum), and are covered by a thin layer of fascia. This fascia must be opened and the artery cleared and ligatured in the usual way, the needle being passed from the nerve. This operation is characterised by Mr GUTHRIE as being "difficult, tedious, bloody, and dangerous."

It is important not to open the fascia covering the deep muscles, for then it is very easy to pass beneath the flexor longus digitorum and so miss the artery altogether. There is often a tendinous intersection in the soleus, which must not be mistaken for its deep tendon.

RÉSUMÉ of the lateral operation:—

1. Make an incision, four inches long, half-an-inch behind and parallel with the inner edge of the tibia.
2. Divide the superficial structures and deep fascia, expose and hook aside the edge of the gastrocnemius.
3. Divide the tibial origin of the soleus, first its muscular fibres and then the glistening tendinous structure covering its under surface, and which forms a sure guide to the vessel.
4. Flex the leg well and extend the ankle to its full extent, hold aside the muscles of the calf, and divide the fascia covering the vessels.
5. Clear the artery and tie in the most convenient way.

(*b*) The **second form** was recommended by the late Mr GUTHRIE, and is known as the mesial or **Direct Incision** (see Fig. 34, *10*). The **patient** is placed in the same position as in ligature of the popliteal artery in the centre of the popliteal space, and the **Surgeon** stands as before. After the superficial structures are divided, the knee should be flexed and the foot extended, in order to relax the muscles through which the operator has to pass to reach

the artery. An **incision**, six or seven inches long, is made in the mesial line of the leg, in the course of the vessel, beginning about two inches below the middle of the popliteal space, and dividing the skin and fascia. The external or short saphenous vein is then separated and held aside, and the *septum* between the two heads of the gastrocnemius is divided to the same extent as the superficial incision, and the two heads separated. The muscular fibres of the soleus are next cut through, and its deep tendon opened as in the last operation; and then the aponeurotic arch covering the vessels is divided, when the posterior tibial nerve will come into view, with the posterior tibial artery and its venæ comites to its *inner* side. The artery is then cleared, and the ligature passed *from* the nerve.

2. **Ligature of the Vessel at the Inner Ankle.**—Here the artery is quite superficial, and its pulsations may be detected during life. It lies between the tendons of the flexor longus digitorum and the flexor longus hallucis, with a vein on either side, and the posterior tibial nerve immediately behind it (that is, nearer the heel); its exact position is at the junction of the anterior with the middle third of a line drawn from the point of the heel to the inner malleolus. The limb is to be placed in the same **position** as in ligature of the artery higher up by the lateral incision; only in the later stages of the operation the foot had better be flexed and everted. The **Surgeon** stands as in the previous operation. Make a semi-lunar incision two inches long, and half-an-inch behind the internal malleolus, towards which the concavity of the incision is to be directed; the incision must not be too near the tibia lest the sheath of the tendons be opened. **Cut through** the skin and superficial fascia, when the specially thick deep fascia, the internal annular ligament, covering the vessels is brought into view and divided. The posterior tibial nerve is then seen, and the artery will be found a little nearer the tibia; separate the artery from its venæ comites and ligature in the usual manner. The structures at the inner ankle all lie in an oblique plane, and unless the operator keep to the concave side of the incision he is very apt to miss the artery altogether. The artery may also be exposed in the lower third of the leg by a vertical incision midway between the internal malleolus and the tendo achillis; in this situation it will be found lying on the flexor longus digitorum.

Branches.—(1) Nutrient to tibia—this is the largest nutrient branch in the body; (2) peroneal; (3) muscular; (4) communicating to peroneal; (5) internal calcanean, several large branches which are distributed to the parts about the heel; and (6) the plantar arteries.

The Peroneal Branch requires special notice. It is often as large as, or even larger than, the posterior tibial artery, and arises from that vessel about an inch and a half from its origin. At first it passes obliquely outwards towards the fibula, and then passes downwards behind, and lying close to that bone until about two inches above the ankle, where it divides into its terminal branches. It first lies on the tibialis posticus, and then passes into the substance of the flexor longus hallucis, in which it lies for the rest of its extent. The artery may be ligatured by the same incision as that recommended by GUTHRIE for ligature of the posterior tibial artery. The posterior tibial nerve forms a safe **guide** to either of these vessels; it lies almost exactly between, and in close relation to them both—the posterior tibial artery lying immediately to its inner side, while the peroneal branch occupies the same position on its outer side. The structures divided, therefore, are the same in both cases. It may also be reached in the middle of the leg by an **incision** three inches long, parallel with and a finger's breadth behind the outer border of the fibula. After the superficial structures are divided, cut through the fibular origin of the soleus, and then separate the flexor longus hallucis from its origin, and towards its inner edge the vessel will usually be found. For this operation the **leg** must be flexed and laid on its inner side and the **Surgeon** stands on the outer side.

Branches of the Peroneal Artery.—(1) Muscular; (2) nutrient to fibula; (3) communicating to posterior tibial; (4) the anterior peroneal, which is given off about two inches above the ankle, pierces the interosseous membrane, and passes down in front of the fibula to the outer ankle, and there anastomoses with the external malleolar of the anterior tibial and tarsal branches of the dorsalis pedis; and (5) terminal branches, which pass down to the external malleolus, and anastomose with the external malleolar, external plantar, and tarsal arteries. It will be noticed, therefore, that in wounds of the plantar arch, on account of the anastomoses

of the peroneal and the anterior peroneal arteries, blood would still reach the arch very freely, even after ligature of both the anterior and posterior tibials.

Collateral Circulation (see Fig. 30).—When the **Posterior Tibial** artery is tied at its *upper part*— 1. By the communicating branch between the posterior tibial and the peroneal (29). 2. Muscular branches of the posterior tibial anastomosing with muscular branches of the peroneal. 3. Malleolar branches (30) of the anterior tibial anastomosing with the anterior peroneal (28), and terminal branches of the peroneal (36), and calcanean branches of the posterior tibial. 4. The communicating branch of the dorsal artery of the foot (33), anastomosing directly with the external plantar (31) from the posterior tibial. 5. The tarsal and the metatarsal branches of the dorsal artery of the foot, anastomosing at the sides of the foot with the external (31) and internal (32) plantar arteries. 6. The perforating branches of the plantar arch anastomosing with branches of the metatarsal branch of dorsal artery. When the artery is ligatured at the *lower part*, the collateral circulation is carried on by anastomoses 2 to 6, inclusive, of above. When the **Peroneal** artery is tied, the collateral circulation will be carried on chiefly by the first three anastomoses enumerated above.

ANTERIOR TIBIAL ARTERY.

Origin.—From the bifurcation of the popliteal artery at the lower border of the popliteus muscle. **Extent.**—From its point of origin to the middle of the ankle joint, where it becomes the dorsal artery of the foot. **Course.**—It passes forwards between the two heads of the tibialis posticus, and then through the opening *above* the upper part of the interosseous membrane, and then passes downwards obliquely towards the ankle joint. Its course may be indicated by a line drawn from the inner side of the head of the fibula to a point midway between the internal and external malleoli. In its upper third the vessel lies deeply, in its lower two thirds it is more superficial. **Relations.**—It is *covered by*— (1) The skin; (2) superficial fascia; (3) deep fascia; (4) the anterior tibial nerve crosses it once or twice; (5) near the ankle *it is* crossed by the tendon of the extensor proprius hallucis. It

is also overlapped by the fleshy bellies of the contiguous muscles. On its *inner side*—(1) The tibialis anticus; (2) near the ankle the extensor proprius hallucis. On its *outer side*—(1) The anterior tibial nerve, at the upper part of the vessel; (2) extensor longus digitorum for about two inches; (3) the extensor proprius hallucis; (4) anterior tibial nerve, at the lower end. It *rests on*—(1) The interosseous membrane in its upper two thirds; (2) the tibia in its lower third; (3) the anterior ligament of the ankle joint. The anterior tibial nerve, one of the three terminal branches of the external popliteal, winds round below the head of the fibula, between the bone and the peroneus longus, lying in close relation with the bursa between the tendon of the biceps and the external lateral ligament, and then passes beneath or through the extensor longus digitorum to join the vessel.

Like the radial, which it resembles in many points, it may be tied in three places—1. In its **upper third**, where it lies between the tibialis anticus and the extensor longus digitorum, resting on the interosseous membrane with its nerve to its outer side. 2. In its **middle third**, where it lies between the tibialis anticus and the extensor proprius hallucis, and still resting on the interosseous membrane, with its nerve probably in front or to its inner side. 3. At its **lower third**, where it lies between the same two tendons, but is now resting on the tibia with its nerve once more to its outer side. The **patient** should be recumbent, as usual, his knee should be flexed, so that the sole of his foot rests flat on the operating table; pillows, or some other support, should be placed in the angle formed by the leg and thigh, and the whole steadied by an assistant. If preferred, the leg may rest on the table fully extended and the toes well inverted. In the deeper part of the dissection the ankle must be flexed freely to relax the muscles on the anterior aspect, and an assistant should be prepared to keep them apart by broad copper spatulæ at the upper or fleshy part of the leg, but in the lower or tendinous part blunt hooks may be substituted for the spatulæ. The **Surgeon** stands in front and to the outer side of the limb.

1. In the Upper Third.—To tie the vessel in its upper third an **incision** four or five inches long should be made in the line of the vessel, along the outer margin of the tibialis anticus muscle,

beginning one inch below the head of the fibula. Another way is to carry the incision from near the edge of the tibia, downwards and outwards, obliquely across the line of the vessel towards the external malleolus; by this incision one more easily detects the inter-muscular space separating the tibialis anticus from the other muscles. In this operation the **guide** is the anterior tibial muscle. Divide the skin and fascia, and expose the muscular aponeurosis. The inter-muscular septum between the tibialis anticus and the extensor communis digitorum (the long extensor of the great toe, not arising so high up on the fibula as this muscle) is next to be found and divided to the same extent as the superficial incision; great care is necessary lest the septum between the common extensor and the peroneus longus be opened instead of this one, and so the operator be led away from the artery, but the proper septum is the *first* white line from the anterior edge of the tibia. To prevent such a mistake, it will be well to bear in mind that the septum between the tibialis anticus and the common extensor is very *weak*, so that the two muscles are very readily separated; while the septum between the common extensor and the peroneus longus is very *strong*, so that these muscles are separated with difficulty (see Fig. 34). This is all the more important to remember, because the common extensor is very narrow above, and the operator is very apt, therefore, to open the septum between it and the peroneus longus. The ankle being flexed the two muscles—the tibialis anticus and the extensor communis digitorum — are separated and held aside with copper spatulæ, and the artery is then found lying on the interosseous membrane, with the anterior tibial nerve to its outer side. It is separated from its venæ comites, and its sheath opened and the vessel cleared, and the ligature passed from the outer side. It is rarely, if ever, tied at at its upper part in the living body, except for a wound, which is then, of course, taken as the guide to the vessel. Were it, however, considered necessary to do so, make the patient throw the tibialis anticus into action by flexing the ankle or inverting the foot before he is put under an anæsthetic, and mark its outer border. It is better in making the skin incisions to make them slightly oblique, downwards and outwards, as it will then be easier to find the septum between the anticus and the extensor

communis digitorum. The breadth of the muscle in an ordinary-sized individual may be regarded roughly as two finger-breadths.

2. **In the Middle Third.**—The steps of this operation resemble very closely those of the previous one. The **incision** need not be quite so long, nor so far from the anterior border of the tibia, and when the deep fascia is opened take the tibialis anticus as the **guide.** Flex the ankle and separate the flexor proprius hallucis from the tibialis anticus, when the vessel will be exposed resting on the interosseous membrane. Separate it from its venæ comites and anterior tibial nerve, and ligature *secundum artem.*

3. **In the Lower Third.**—The vessel is more easily reached in this situation, as the bulk and depth of the muscles are much diminished. An **incision** should be made in the line of the vessel two inches long, about three-quarters of an inch from the anterior edge of the tibia upon the outer side of the tendon of the tibialis anticus, and parallel with it; at this point the tibialis anticus is much narrower than it is at the upper part of the leg, and the extensor proprius hallucis lies to the outer side of the artery. At this point, therefore, the artery lies between the tendons of the tibialis anticus and the extensor proprius hallucis, with the nerve to its outer side, and rests on the lower end of the tibia. The steps of the operation are similar to those described above. When the tendons are exposed, flex the ankle and with blunt hooks hold them apart while the vessel is separated from the surrounding structures and ligatured.

Branches.—(1) The anterior tibial recurrent; (2) muscular; (3) internal malleolar; (4) external malleolar, which is larger than the internal, and anastomoses with the anterior peroneal artery.

Collateral Circulation.—For this, see anastomoses, from 3 to 6, inclusive, in "Collateral Circulation" under the "Posterior Tibial Artery."

Dorsalis Pedis Artery.—Origin.—It is the direct continuation of the anterior tibial artery. **Extent.**—From the centre of the instep, beneath the anterior annular ligament, to the base of the metatarsal bone of the great toe, where it divides into the communicating branch to the sole of the foot and the dorsal artery of the great toe. **Course.**—Its course is from the centre of the instep to the cleft between the first two toes. **Relations.**—It is

simply *covered by* the integumentary structures, and crossed near its point of bifurcation by the innermost tendon of the extensor brevis digitorum, which may be taken as the **guide** to the vessel. It *lies between* the tendons of the extensor proprius hallucis and the extensor communis digitorum, and has the anterior tibial nerve to its outer side. It *rests on* the bones of the tarsus and their dorsal ligaments. It may be tied in the upper part of its course by an **incision** an inch and a half long, in the line of the vessel, on the outer side of and parallel with the tendon of the extensor proprius hallucis. To reach the vessel it is only necessary to cut through the skin, superficial, and deep fascia, and hold aside the innermost tendon of the extensor brevis.

Branches.—(1) Tarsal, (2) metatarsal, (3) communicating, and (4) dorsalis hallucis.

Collateral Circulation.—See anastomoses, 4 to 6, inclusive, under "Posterior Tibial Artery."

The External Plantar Artery and Plantar Arch.—The course of this vessel may be mapped out on the sole of the foot as follows:—A line drawn from the tip of the internal malleolus to the point of the heel would pass through its origin, which is rather nearer the malleolus than the heel. From this point it runs forwards and outwards, taking a slightly arched course, with the convexity outwards, to the base of the fourth inter-metatarsal space; this forms its superficial part, and it is covered by the superficial structures and plantar fascia, the abductor hallucis, and the flexor brevis digitorum muscles. From this point its course is deeper; it turns round the outer border of the accessorius, and runs forwards and inwards to the posterior part of the first interosseous space forming the plantar arch, lying upon the interossei and the bases of the metatarsal bones. The arch is completed by the communicating branch from the dorsalis pedis, and is covered by the first three layers of muscles of the sole of the foot.

In regard to **Wounds** of this arch the same principles of treatment must be adopted as in wounds of the palmar arches. The vessel is deep—the fascia over it is dense,—the tendons, muscles, and nerves are numerous and important; a large scar on the sole of the foot is a serious thing, and, therefore, before lightly undertaking the operation of tying the vessel at the bleeding point these

facts must be duly weighed for the patient's sake—for it is not a question of mere operative dexterity. **First,** see that the vessel is more than *wounded*, make sure it is completely divided; if this is not sufficient, then **Second,** use a graduated compress properly applied, combined with elevation of the limb; if even yet it does not stop, probably the best plan is **Third,** to tie the superficial femoral at the "seat of election," *i.e.*, the apex of Scarpa's triangle. This, at first sight, may seem too serious for the occasion, but it is not really so. The ligature of the superficial femoral is not surely such a serious thing as ligature of *at least three* vessels below the calf, probably more, and, after all, a considerable risk of failure; while ligature of the single vessel in the thigh will almost certainly be sufficient. At the same time it should only be done when everything else has failed. **Fourth,** just as in the hand, the plantar arch may be ligatured directly from the dorsum of the foot after removal of a part of one or other of the metatarsal bones overlying the vessel (Delorme). An attempt might also be made to secure the bleeding point by forcipressure.

CHAPTER XII.

AMPUTATIONS—INSTRUMENTS.

1. **Means to Command Hæmorrhage** during the operation, as—(*a*) **Thumbs** of a trustworthy assistant, *e.g.*, on the femoral artery as it lies on the ilio-pectineal eminence at the pelvic brim, in amputation of hip; the thumb of an assistant, or a **padded key** (a strip of lint is to be wrapped round the ring of the key, which is then used to compress the artery, while the other end is well padded to prevent it injuring the assistant's hand), or **Spence's special compressor,** to compress the subclavian against the first rib in amputation or excision of the shoulder joint. (*b*) **Lister's bloodless plan,** of first emptying the limb of blood by simply elevating it for about a minute, with or without rubbing, in the direction of the venous flow, and then applying Esmarch's elastic band or Petit's tourniquet without the pad. In using this method there must be no circular compression of the limb; the leg, for example, is to be held vertically by the assistant placing one hand on the heel and the other on the patella: in this way the flow through the veins is not in any way impeded. LISTER has shown that, by simple elevation not only is the outflow through the veins increased, by the action of gravity, but that the inflow is diminished, on account of the contraction of the arterial walls. Petit's tourniquet with the pad alone, as it was formerly used, compresses both the main artery and the smaller vessels very effectually. One disadvantage is that it also arrests the flow of blood in the superficial veins, which are thus soon filled, and bleed a good deal during the early stages of the operation; and hence, therefore, the tourniquet should not be tightened until the operation is about *to be commenced.* (*c*) **Esmarch's bloodless plan.**—He applies a

broad elastic bandage, spirally, from the distal extremity of the limb to be operated upon to the point at which the elastic band or tourniquet is to be applied; after applying the tourniquet he removes the broad bandage. By this means the limb is squeezed absolutely bloodless and remains so during the whole operation. Several **objections** have been urged against this plan:—(1) It is said to predispose to reactionary hæmorrhage, probably from some injury to the vaso-constrictor or the vaso-dilator nerves, so that the vessels do not contract and retract as they otherwise would, and as there is absolutely no bleeding during the operation they cannot be seen and secured so well as in other methods. Again, one of the essential conditions for the natural arrest of hæmorrhage is absent, viz., blood, so that the small vessels have not an opportunity to seal themselves during the progress of the operation. (2) In cases of putrid sores, or soft vascular malignant growths, it is not advisable to force the noxious products further up the limb. (3) Where the elastic tourniquet is used it is impossible to loosen it a *little*, so as to let just enough blood down to make the open vessels visible, and give the smaller ones an opportunity of being plugged naturally by blood clot. With plenty of assistants this is no great disadvantage, but in operating single-handed it would be a serious inconvenience to the Surgeon, and risk to the patient, from loss of an unnecessary amount of blood. Screw tourniquets, such as Petit's, have not this disadvantage, as they can be slackened or tightened at will.

2. **Straight Bistouries,** narrow and broad—narrow-bladed, for example, in amputation of the phalanges of the fingers and metatarsals of fingers and toes.

3. **Scalpels,** not too broad-bladed.

4. **Cutting Pliers** of various shapes, to be used in cases where the bone has splintered during sawing, and in cases where it may be deemed expedient to remove the heads of the metacarpal bones. In using the pliers the *flat* side is to be placed next the part to be preserved.

5. **Amputating Knives** of various lengths. If for transfixion, their length should be from one and a half to twice the diameter of the part to be amputated. Specially shaped knives are made for the circular method, although it is not by any means necessary to

use them, as an ordinary transfixion knife does perfectly well. The blade is of the same breadth throughout; it is not sharp-pointed like a transfixion knife, and, further, it is slightly curved towards the point, the concave side of the curve, of course, being towards the edge of the knife. By means of this knife it is supposed that the operator can encircle the limb more easily. In making flaps by dissection, the skin and the subcutaneous fatty tissue must be raised as one layer, and in doing so the edge of the knife must always be directed *away from* the skin (just the opposite to the plan used in the dissecting-room) and towards the part to be removed, never towards the under surface of the flap. By this means we avoid cutting the small vessels in the subcutaneous fat that go to nourish the skin, and are, therefore, less likely to cause sloughing. The skin itself must be cut at right angles to the surface to avoid undermining or shelving of the edge.

6. **Saws**, with strong, broad blades, fine teeth properly set, and strong, movable backs; also various other kinds for special operations, as finger and metacarpal saws. In sawing the bone, previously cleared by the knife, place the *heel* of the saw on the bone, the blade being steadied by resting against the second joint of the left thumb, and then draw it with *firm* pressure towards you, in order to make a groove for it to run in, and thus prevent it slipping about; after this, use long, *light*, sweeping movements, from point to heel, the assistant in the meantime taking care to hold the bone in such a way that he does not lock the saw by raising it, nor snap it through, before complete division, by depressing it. Another excellent way to avoid splintering is to direct the assistant to make gentle extension in the long axis of the bone being divided. In limbs with two bones of equal size they should be sawn through together; if of unequal size, the smaller should first be divided, and in the case of the femur the saw should be so manipulated that its posterior ridge *(linea aspera)* is divided before the rest of the bone is entirely sawn through. In all cases where there is but one bone, if the saw is gradually changed from the horizontal to the vertical, the bone is less likely to snap across if improperly held. **To clear the bone**:—(1) *Where there is but one bone*—For this purpose use a firm, circular sweep of the knife, from heel to point, round the *under* segment of the bone, and then another sweep round its upper

segment. (2) *Where there are two bones*—First clear by sweeps of the knife round both bones, as in the last method, and next cut the interosseous membrane and tissues between the bones in a figure-of-eight-like way between and round the bones, always taking care not to let the edge of the knife be directed upwards between the bones, lest the interosseous vessels be divided too high up for easy ligature.

7. **Ordinary Artery** and **Torsion Forceps.**

8. **Tenacula.**—Tenacula are required in some operations where the vessel cannot be secured by the ordinary forceps, as in cases when amputation is performed at a point where an artery is passing between two bones, and is apt to retract so much that it cannot be caught by ordinary methods, but must be secured by hooking up a little of the surrounding tissues with the artery. This is best done by a tenaculum plunged deeply through the tissues, and made to transfix the vessel which is then pulled forward, and the tissue, with the artery, tied under the tenaculum. Cases in point are met with in amputation just below the knee, where the *anterior tibial* artery comes through between the two bones; also in amputation just below the elbow joint, where the *posterior interosseous* artery passes through between the radius and ulna. A like method of securing vessels may be necessary in amputating through chronically inflamed parts, or in places where the coats of the vessels are diseased, so that they cannot be pulled out sufficiently for the application of the ligature. A curved needle threaded with catgut may also be used for a similar purpose, and is more generally used now-a-days than the tenaculum.

9. **Lion Forceps.**—Used, for example, in SYME's amputation at the ankle joint, CARDEN's at the knee, and JORDAN's at the hip.

10. **Periosteum Elevators** may be required in many amputations, *e.g.* hip, thumb, etc.

11. A good stock of **Wells's** or **Péan's Forceps,** for the temporary arrest of hæmorrhage.

12. **Ligatures** and **Needles,** both for catgut and wire sutures. The needle for wire sutures has deep lateral grooves near the eye, so that the wire may lie smoothly, and not obstruct the passage of the needle through the tissues.

13. **Scissors.**

14. **Retractors** of strong calico split at one end. In cases where there is but one bone, split it into two tails; where there are two bones it must be split into three tails. This method of retracting the tissues is sometimes used in the circular and in the combined flap and circular plans of amputation, but is not necessary in the pure flap amputations, the fingers of an assistant being all that is required. By this means, not only are the soft parts retracted, but are, at the same time, protected from the teeth of the saw, and from impregnation with sawdust.

15. **Dissecting Forceps.**

Assistants.—The number required will necessarily vary much. The following is a fairly complete list:—

No. **1**, to administer chloroform.

No. **2**, to empty the limb of blood and command the main artery, take charge of the tourniquet, etc.

No. **3**, to attend to the flaps, to retract, etc.

No. **4**, to hold the part to be removed.

No. **5**, to assist operator—keeping the wound free of blood, and catching up small vessels with Wells's or Péan's forceps, and ligaturing the vessels as they are seized by operator.

No. **6**, to hand instruments to operator and his assistant.

No. **7**, to wash sponges and supply them as required to No. 5 or operator.

In a well appointed hospital it is a simple matter to find plenty of assistants; but in many cases, *e.g.*, in country practice, it is impossible, and the operator has to do the work almost single-handed. Hereafter, in describing the different operations, to avoid unnecessary repetition, I shall only mention the duties of the assistant who has charge of the leg, with an occasional reference to the one who has to look after the flaps.

DIFFERENT METHODS.

I. **The Circular Method** (BENJAMIN BELL).—In the old and original circular method all the tissues were cut through at one level. This was before the days of tourniquets or chloroform. From this crude origin there was a gradual progress up to the time *when it may be* said to have been perfected by BELL, and was from

thenceforth known as the "*triple incision.*" The integument being drawn up by an assistant, who grasps the limb with both hands, the operator divides the skin and fat by a single circular sweep of the knife; the skin and fatty tissue are then dissected back as one layer for a distance equal to half the diameter of the limb. The muscles are next divided at the level of the retracted skin by another circular sweep of the knife, and retracted for a distance varying from one to two inches, according to the thickness of the limb; and, lastly, the bone is cleared and sawn as high up as possible. In this way, when the soft parts are brought into position, the bone is at the bottom of a deep cavity, the object being to prevent the "sugar-loaf stump." The name, "triple incision," was given to this method by Mr HEY, who also advised that the posterior muscles should be cut longer than the anterior, to compensate for their greater retraction, as they are cut further from their origin, and therefore retract more than the anterior. The *first* incision is through the skin and fat only; the *second*, through the muscles; and the *third*, round the bone to separate the muscles and clear it for the application of the saw. **Advantages**—(1) All the blood vessels are cut transversely, and are therefore more likely to contract and retract well and prevent unnecessary hæmorrhage; (2) in fleshy limbs it is specially good, as it prevents redundance of useless muscle; (3) the surface of the wound is smaller than in the flap method. **Disadvantages**—(1) The cicatrix is opposite the end of the bone and adherent to it; in the lower extremity this is a serious disadvantage, as the patient can never bear any part of the weight of the body upon it, and besides it often causes a painful and tender stump. (2) It is a tedious and therefore a very painful operation; this, however, is of no consequence now, as the patient is anæsthetised. (3) In stitching up the wound puckered corners are left at each end, the skin of the two sides not lying smoothly in apposition.

II. **The Flap Method.**—By flaps, formed either by cutting from without inwards, (*i.e.*, by dissection), or from within outwards (*i.e.*, by transfixion). The number, size, and position of the flaps vary much; the flap furthest from the main artery should be cut first. **Advantages**—(1) It is more easily and rapidly performed as compared with the circular, and is therefore less painful to the

patient; but this, as already stated, is of little consequence now-a-days. (2) It gives a good muscular cushion to cover the end of the bone; this advantage, however, is more fancied than real, for Surgeons are inclining to the belief that much muscular tissue in a stump is an unmixed evil. The muscular tissue, it is said, atrophies and finally disappears, so that, from this point of view, the circular would be as good as the flap. Still one must remember that, although the *muscular* tissue disappears, yet it leaves behind it resistant *fibrous* tissue. (3) At joints flap amputation is better than circular. (4) It is capable of innumerable modifications. **Disadvantages**—(1) Many of the vessels are cut obliquely, and therefore do not retract and contract so much as they would were they cut transversely as in the circular method; the main artery may even be split or punctured. (2) Previously it often failed to produce so good a stump as the circular method, on account of the irregular retraction of the different muscles. (3) The surface of the wound is larger than in the circular amputation. (4) The disadvantage of a thick muscular flap. In all flap amputations care must be taken not to split or puncture the main artery.

Transfixion *versus* **Dissection.**—**Transfixion**—In muscular limbs the flaps are apt to be redundant, heavy, and easily displaced; further, the muscles "start," and this delays primary union, and is very painful to the patient. It is more easily and speedily performed, the muscles and deeper parts are smoothly divided, but it is more difficult to form a well-shaped flap. When there is much muscular tissue it has to be tucked in to allow the skin surfaces to meet; this causes tension, gaping of the wound, giving way of the stitches, and many other evils. The skin, too, is often divided very irregularly as, being so elastic, it stretches before the knife. During transfixion operations the limb should be held so as to relax the parts that are to be pierced. **Dissection**—The flaps can be shaped better, and one can better choose the relative proportions of muscle and skin entering into the flaps. It is less easy to perform and takes longer time. In many places it is impossible to transfix, as the bone is too thinly covered, *e.g.*, anterior aspect of the leg, and the posterior aspect of the fore-arm; in these situations the flaps must be made by *dissection.* In cases of smash requiring amputation the flaps must

be shaped by dissection, otherwise the tendons and muscles being loosed by the injury, yield before the knife and are dragged out.

III.—**Combination Methods** *(Flap and Circular).*

1. **Modified Circular** (SYME).—Two semi-lunar incisions, with their convexities downwards, are made through the integuments, forming two short flaps, each equal to one-quarter of the diameter of the limb; the flaps are then dissected up and the skin and fat above the bases of the flaps raised, as in the circular method, for a distance equal to the length of the flaps. The muscles are thus exposed, as in the circular method, at a distance equal to half the diameter of the limb above the convex ends of the flaps, and are then divided by a circular incision on a level with the retracted skin, the superficial layer of muscles on the posterior aspect being divided one-quarter of the diameter of the limb lower down than those on the anterior aspect—*i.e.*, on a level with the base of the skin flaps. The soft parts are then forcibly retracted, and the bone cleared and sawn higher up.

The only difference between the "modified circular" of SYME and the "triple incision" of BELL consists in the mode of dealing with the skin; in fact, it is just the circular method with a small Λ-shaped piece of skin removed from each side. The "modified circular" is specially useful when amputating through cone-shaped parts, as, for example, just below the calf. In that position, were the ordinary circular method used, it would be impossible to retract the skin sufficiently without splitting it; but the modified circular renders its retraction easy. In the upper extremity also it has the great advantage of giving the longest possible stump; and the fact that the scar is opposite the end of the bone is not such a serious objection in the upper extremity as it is in the lower. It is also useful in amputations through the fleshy parts of the thigh, and in operations below the knee. It gives the longest possible stump, and the smallest possible wound compatible with good covering of the bones.

2. **Teale's Method** *(by long and short rectangular flaps).*—The long flap is folded over the end of the bone, and should not contain the large blood-vessels and nerves of the limb; and its length and its breadth should be each equal to one-half the circumference of

the limb. The short flap should only be one-fourth the length of the long one, and should contain the large blood-vessels and nerves. In performing a pure TEALE, the measurements must be carefully made, and the flaps outlined on the limb with ink, before the amputation is commenced. Whether the short flap is anterior, lateral, or posterior, will depend on the position of the large blood-vessels and nerves; *e.g.*, at the ankle the short one will be posterior, while at the wrist it will be anterior, and just above the elbow joint it will be internal. This method is chiefly used at the ankle and immediately above the knee. The **advantages** claimed for this method are—(1) The bone is well covered by sound tissue. (2) The cicatrix is situated high up on the posterior aspect. (3) It provides a dependent opening for the escape of discharges. (4) The patient can bear a considerable part of his weight on the end of the stump. Its **disadvantages** are—(1) The great length of the flaps. Because of this the bone must be sawn higher up than in many other methods of amputation, *e.g.*, SYME'S "modified circular," and one would, therefore, be guilty of the serious error of removing more of the sound limb than is absolutely necessary, thus giving a less useful stump, as well as increasing the risk of the operation, since the nearer we approach the trunk the more fatal do such operations become. This is very marked at parts where the limb at the point of section is particularly fleshy; when the limb is spare this disadvantage is not so marked. (2) The *square* form of the flaps. This necessitates much time and great pains to make them fit well. (3) The anterior flap is doubled upon itself, and there is, therefore, great risk of impairing its vitality. (4) In amputating for malignant disease there is greater risk of recurrence in the long flap than in two shorter ones, the bones being divided at the same level. (5) So also in cases of great injury to the soft parts this method would be impracticable, as it would necessitate section of the bone high up. (6) Should the flaps fail to unite by the first intention, the heavy anterior flap will give rise to considerable trouble in the after treatment. (7) The cut surface is extensive.

3. **Spence's Method.**—By a long anterior flap; but the flap is *not doubled upon itself*, nor does it require to be so *long* as in TEALE'S method; it simply folds loosely over the posterior segment of the *stump, and, when* healed, the cicatrix is on the posterior aspect.

Its breadth should be fully one-half the circumference of the limb, and its free end gently *rounded*. A flap four inches in length will be sufficient for a limb twelve inches in circumference. On the posterior aspect the soft parts are divided obliquely towards the bone, beginning three inches lower than the level of the base of the anterior flap. The whole of the soft parts are then retracted, and the bone is sawn two inches higher up than the base of the flaps. This method is almost restricted to the lower third of the thigh, and is specially valuable in muscular limbs. It is interesting to observe the gradual and silent lengthening of the posterior flap in Mr SPENCE's amputation. As introduced, there was no posterior flap; in his later years he cut the tissues behind obliquely, so as to form a short posterior flap; and in the present day operators make a square posterior flap at least half the length of the anterior. This gradual lengthening is probably due to the fact that, in amputations through the lower third of the thigh, a flap length, at least equal to twice the diameter of the limb at the point where the bone is sawn, must be provided, instead of the usual one and a half. The **advantages** of this plan over TEALE's method, so far as regards the length of the stump, are more apparent than real. If SPENCE's *flap* be two inches shorter than TEALE's, he saws the *bone* two inches higher up than the base of the flap, whereas TEALE saws the bone on a level with the base of the flaps. But SPENCE's is more easily performed, provides as good a covering to the bone, the cicatrix is in a good position, the wounded surface is less, and should it fail to heal by the first intention it is more manageable.

4. **Carden's Method.**—A rounded anterior flap composed of skin and subcutaneous tissue only. Its form and position resembles very closely SPENCE's anterior flap. Before sawing the bone the soft parts are retracted a little; there is no posterior flap. This method is used principally at the knee joint in amputation through the bases of the condyles. In CARDEN's amputation, as in SPENCE's, the same gradual development of a posterior flap is observed.

5. **Lister's Method** resembles TEALE's somewhat, only LISTER takes the flaps more equally from the anterior and posterior surfaces. His method has all the advantages of TEALE's plan, without its disadvantages. The anterior flap is about two-thirds of the diameter of the limb at the point where the bone is to be sawn, and the

posterior, half that length; as compared with TEALE, there is less sacrifice of sound limb. The scar is situated behind, and there is a free exit for discharges. This method is best suited for amputation through the fleshy parts of the fore-arm, leg, and thigh. The flaps are made by dissection, and are chiefly composed of integumentary structures; if it be deemed necessary, however, some muscle may be taken up at the base of the anterior flap, to lessen the risk of sloughing. The posterior flap is composed entirely of the skin, subcutaneous tissue, and fat. The flaps are then raised and the muscles divided by a circular sweep of the knife, and retracted for a distance equal to one-quarter of the diameter of the limb, and the bone divided at this point. Should the retraction of the flaps prove difficult, it may be necessary to carry an incision upwards from the angle of the flaps to the point at which the bone is sawn, either on one or both sides—somewhat after the manner of TEALE, only he makes the lateral incisions at the beginning of the operation. In the thigh it is found necessary to retract the muscles for a distance equal to one-half the diameter of the limb. Further, in the lower thirds of the leg and fore-arm it is necessary to make the anterior flap equal in length to the diameter of the limb, in order to ensure a good covering for the bone, and at the same time make certain that the cicatrix shall be situated behind; the reason is, that the *bones* form a greater proportion of the thickness of the limb in these situations.

IV. **The Oval Method.**—This plan is specially adapted for disarticulation of the fingers and toes, shoulder and hip. It is really a circular amputation with a straight incision up one side of the limb, with the angles, where the straight and the circular incisions meet, rounded off. When the straight incision is longer than usual, it is often called the "racket-shaped" incision, which may be used, for example, in amputation of the metatarsal bone of the little toe or thumb.

The best method of amputating the **Lower Extremity** (except where there are special methods adopted, such as SYME'S at the ankle) is, in my opinion, by anterior and posterior flaps made by dissection, with muscular tissue taken up towards their bases to prevent the skin sloughing—say, one diameter of skin and subcutaneous *tissue only, and half* a diameter with muscle as well. In the case

of MACKENZIE'S amputation at the ankle joint, however, this rule does not hold, as we must go down to the bone at once and take muscles and all at the very apex of the flap for the sake of preserving the posterior tibial and plantar arteries. The total flap length should be equal to a diameter and a half of the limb at the point where the bone is sawn, the posterior flap being about one-half the length of the anterior, and both flaps should be almost square, the anterior simply having its corners rounded slightly. The breadth of the anterior flap should always be fully one-half the diameter of the limb. In regard to the diameter and circumference of limbs, it should be remembered that the diameter is rather less than one-third the circumference ($D = C \div 3{\cdot}1416$). Of course, theoretically, flap length equal to one diameter of the limb ought to cover the bone; but on account of elasticity and consequent shrinking of the skin, and the contraction of the muscles, one must, at least, provide another half diameter, and in some cases even another whole diameter. In the method above advocated, supposing the limb to be eighteen inches in circumference at the point where the bone is to be divided, we may either make an anterior flap six inches long, and a posterior three inches, and divide the bone at the bases of the flaps; or else make the anterior flap four and a half inches long, and the posterior two and a half inches, and then retract the muscles and clear the bone one to two inches above the bases of the flaps, and there divide it.

In the **Upper Extremity** the best method of amputation is by the "modified circular," or else equal anterior and posterior flaps made by dissection, the total flap length being equal to a diameter and a half of the limb at the point where the bone is divided.

SPECIAL POINTS IN REFERENCE TO AMPUTATION.

Whatever method may be adopted, the following objects must be clearly kept in mind:—

1. Use every possible endeavour to save the patient's life, and give him the most useful limb—or stump rather—afterwards. Mere "brilliancy" is not to be thought of in amputating; it is probably one of the worst qualifications a Surgeon could well have. A living brother-man is at your mercy, who probably has his bread to win, and not only that, but perhaps also is the sole

support of a wife and children. It behoves a Surgeon therefore, beyond all things, to keep in mind the golden rule formulated by One who was at once the most successful Surgeon, the greatest Teacher, and the truest Man that ever lived—"Therefore, all things whatsoever ye would that men should do to *you*, do ye even so to *them*."

2. Provide a sufficient covering of healthy integumentary structures, with as little loose muscular tissue as possible. The total amount of flap length should be equal to one and a half times the diameter of the limb, at the point where the bone is sawn. The large nerves should be gently drawn out and cut off short at the level of the divided bone, to avoid their being included in the cicatrix, causing a "painful stump," more especially as they show a great tendency to grow at the proximal end, forming bulb-like neuromata. Tendons are also to be cut short if they project unduly, but should not be drawn out before being cut, as their adhesion and blending with the tissue in the neighbourhood of the scar will add greatly to the chances of procuring a mobile stump; this is very well shown in SYME'S amputation at the ankle. The flaps should, as a rule, be made by dissection, and the anterior is to be about twice the length of the posterior. A very important matter is to secure a *mobile* stump, which cannot be done with insufficient flap length.

3. The scar should be situated towards the posterior part, and for this purpose the long anterior and the short posterior flaps are best suited, as the bones in the thigh and leg are situated nearer the front than the back. By this means the scar is better protected from pressure and injuries, and the patient may be able to bear a considerable part of the weight of his body upon the stump; further, the flexors retract more than the extensors, and this will pull up the scar still further. In the leg and thigh, when the posterior muscles are cut far from their origin, the flaps may be made of almost equal length, and yet, when the stump is healed, the cicatrix will be situated on the posterior aspect—(1) Because the bones are nearer the front than the back; and (2), in healing, the posterior muscles contract more than the anterior.

4. Have a free exit for discharges. For this purpose the *position of the longer* flap will necessarily depend on the position

of the limb during the after treatment. In the fore-arm the long flap should be taken from the dorsal surface—though, as a matter of fact, the *dorsal* surface of the fore-arm corresponds to the *anterior* surface of the leg. Elsewhere it must come from the anterior surface, provided there is no special reason to the contrary—as in amputations of the foot, ankle, and wrist joint; in these situations the opportunity of getting a pad so fitted by Nature for the purpose intended, having been previously accustomed to bear weight, outweighs every other consideration.

5. Try to save as much of the sound limb as possible, for the nearer we approach the trunk the greater is the danger to the patient; and besides, the longer the stump the more power will he possess over any artificial limb. The longest stumps can be obtained by the "modified circular" or equal anterior and posterior flaps. This, however, must not be obtained at the expense of other equally important principles, as good drainage, posterior position of scar, etc.

Position of the Surgeon.—In regard to the position of the Surgeon during the various amputations many things will have to be considered. For example, in performing *flap amputations*, many Surgeons prefer to stand in such a way that they will be able to control the flaps with the left hand, and if necessary, the main artery, and afterwards the stump—*i. e.*, always on the right side of the limb—trusting to the assistant to steady the limb during the application of the saw; while others prefer to stand on the other side, so that they themselves may grasp the part to be removed in the left hand, and steady it during the use of the saw, while the assistant raises the anterior flap. The latter method will have to be adopted in cases where assistants are few, or where the Surgeon operates single-handed. During *transfixion operations* it will, on the whole, be more convenient to stand on the left side of the limb to be amputated. In operations on the hands and feet, wrist and ankle, the Surgeon will stand in front of and facing the part operated upon. Further, the convenience of bystanders and students must to a certain extent be consulted, the Surgeon standing in such a way as not to obstruct the view any more than he can help. In a general way, it may be stated that in flap amputations by dissection pure and simple, or where the anterior

flap is made by dissection and the posterior by transfixion, as in the upper arm and thigh, he should stand on the right side of the limb to be removed. In circular amputations he may stand either on the right or left side, as may be found most convenient; while in pure and classical transfixion he should stand on the left side of the limb to be removed.

Position of the Patient.—In a general way, in amputating the **Upper Extremity,** the patient should be brought well to the edge of the table, next the operator—the part to be removed projecting beyond it; in amputating the **Lower Extremity,** he should be drawn well down towards the end of the table, so that the part to be removed may project well beyond it, and be held there by an assistant, seated on a low stool in front of the patient—the sound leg being secured by a clove hitch to a leg of the operating table.

Dressing the Stump.—The vessels having been all secured, the surface of the wound should be washed with a warm antiseptic solution, and then sponged dry. After this the edges of the flaps must be adjusted and kept in apposition by sutures; as good as any are the non-absorbable and non-absorbent sutures of horse-hair—the deep sutures consisting of double hairs, the superficial of single; and in both cases, when tying, put the first knot twice through before tightening it, to prevent it slipping or slackening. The **Deep** sutures are known as "*sutures of support and relaxation*," as they bear the strain and relax the *edges* of the wound; the first one should be inserted at the centre of the flap, and others midway between this suture and the angles of the wound, and so on till the flaps are sufficiently supported and relaxed. These deep sutures should get a good hold of the skin and fat for at least an inch from the edges of the wound; sometimes the silver-wire button suture is used for a similar purpose. Between the "deep" sutures finer sutures must be inserted, in order to bring the skin edges into accurate apposition; these **Superficial** sutures are known as "*sutures of apposition or co-aptation.*" In introducing the superficial sutures be careful to avoid tension, in-turning of the cut edge of the skin, or protrusion of pieces of fat or blood-clot between the edges of the wound. After this, *perforated rubber* drainage-tubes must be introduced near the

angles of the wound; they are to be cut level with the skin surface and fastened with a horse-hair suture or safety-pin, to prevent them slipping into the wound. The use of the tube is to avoid tension and pain by removing discharges, and in doing so it also removes the soil in which putrefactive organisms would flourish; the tubes may be removed at the end of twenty-four or thirty-six hours. The wound should now be filled and be again washed out with warm antiseptic lotion by means of a syringe, and then squeezed perfectly dry by means of sponges. The dressings are next applied; a strip of green protective is applied along the wound, over this a few layers of wet gauze, and then a quantity of antiseptic wool, to give gentle support and exercise equable pressure, the whole being kept in position by bandages. Last of all, in order to secure perfect rest, a posterior splint should be applied and bandaged to the limb. Professor CHIENE prefers this splint to be made of fairly heavy sheet lead, with perforations; the perforations are to allow blood to come through, should hæmorrhage occur, as otherwise the stump would bleed into the splint and dressings, and the patient might thus lose much blood before the accident was discovered. The stump may be raised for the first twelve or twenty-four hours, in order to lessen the risk of hæmorrhage, but after this it should be placed in a horizontal position.

CHAPTER XIII.

AMPUTATIONS OF THE UPPER EXTREMITY.

In regard to amputations of the thumb and fingers, the cardinal principles to be kept in mind are—1. To keep up the full breadth of the hand, so that it may retain, as far as possible, its grasping and lifting powers; and, in order to do this, the heads of the metacarpal bones, at least of the second and third fingers, must not be interfered with, for a contracted hand is a weak hand, however shapely it may appear. 2. To save as much as possible, and to maintain the opposability of the thumb or *any* remnant thereof. 3. Not to interfere with the palm. 4. That the ugliest and worst natural appendage is immensely superior, to its possessor, to the most ingenious and artistic artificial hand.

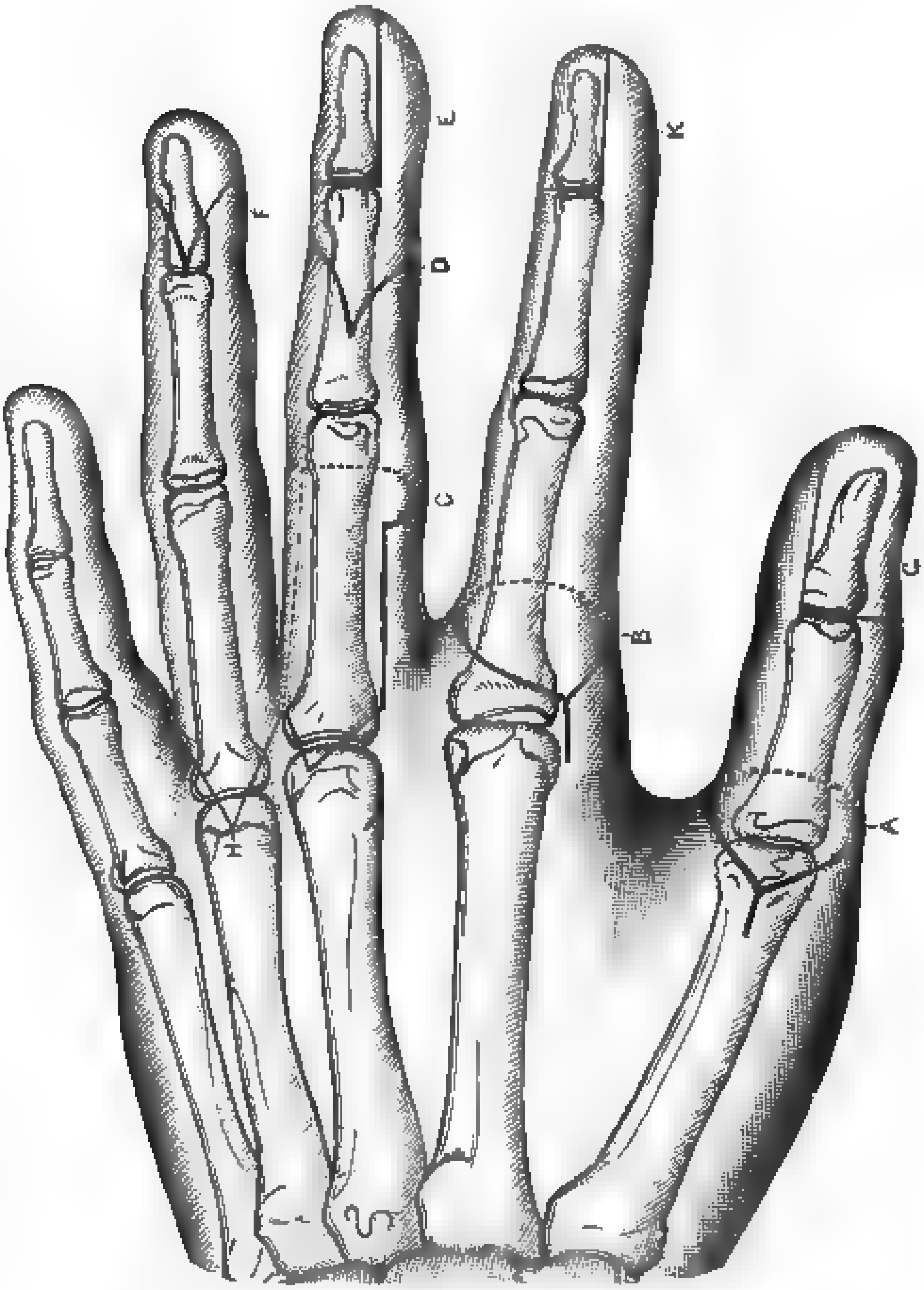
In performing amputations on the **dead body** the following instruments are required :—(1) A proper knife or knives, (2) bone pliers, (3) a proper saw, (4) lion forceps, (5) artery forceps, (6) ligatures, and (7) scissors. They must be all selected before beginning the operation, and placed on a small tray, within easy reach of the operator's right hand. The subject should be brought well to the side of the table in all amputations of the upper extremity.

A TERMINAL PHALANX.

This amputation may be rendered necessary for injury or disease. A very common cause is the result of a bad whitlow. In whitlow, or abscess of the pulp, the bone is very apt to necrose, on account of the close connection between the fibrous tissue composing the pulp and the fibrous periosteum immediately below. The base of the bone, however, usually escapes, because there the tendon of the long flexor is attached, and is surrounded by its sheath, and this, it would appear, protects the periosteum.

Fig. 35.

THE HAND.



A. Amputation of the thumb at the metacarpo-phalangeal articulation by the "oval" method.

B. The same for the index finger. C. Chiene's method.

D. Through a second phalanx. E, G, and K. Through a terminal phalanx, by a single palmar flap.

F. Through a terminal phalanx, by double flap.

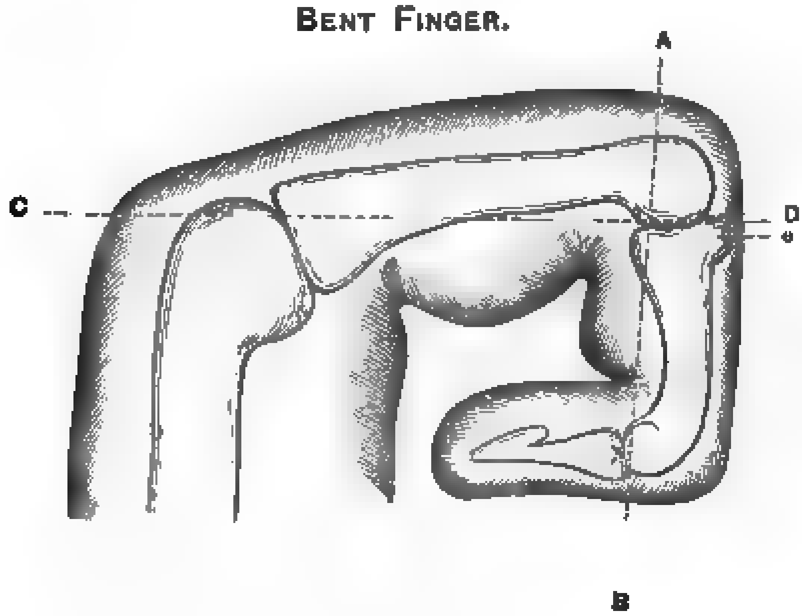
H. Amputation of a finger by the double lateral flap.

It should be observed that the phalangeal joints are *concave*, the concavity pointing towards the tips of the fingers; but that the metacarpo-phalangeal joints are *convex* towards the tips of the fingers.

1st Method—By Single Palmar Flap (Fig. 35, E).—The hand should be emptied of blood by elevation, and an elastic tourniquet applied just above the wrist. It must then be held at a convenient height for the operator by an assistant, who flexes the elbow of the arm to be operated upon, places the fore-arm between his own left side and left arm, flexes the wrist, and places the hand in the prone position; the fingers on each side of the affected one are to be well abducted and turned in towards the palm. The operator should

Fig. 36.

BENT FINGER.



A B and C D—Lines showing how to find the joints between the phalanges.

e—Tubercle at the base of the second phalanx, which may be taken as the guide to that articulation.

stand facing the hand, and must be provided with a narrow-bladed bistoury. He next grasps the tip of the phalanx to be removed between his forefinger and thumb, and bends it to a right angle with the second phalanx, and then by a transverse sweep of the bistoury, from heel to point, opens the joint, which is concave towards the tip of the finger. The usual rule for finding the joint *is a good one*—the joint is on a level with an imaginary line drawn

along the middle of the lateral aspect of the second phalanx, when the finger is held as directed (Fig. 36, A B). The knife is then to be carried round the base of the phalanx, the first and second phalanges in the meantime being extended, while the terminal phalanx is still further flexed as the lateral ligaments are divided. When the knife has cleared the end of the bone, the phalanx being amputated should be fully extended and a flap of sufficient length cut from the pulp. **Structures divided**—Skin, superficial fascia, digital vessels and nerves, extensor tendon, ligaments of the joint, and tendon of the flexor profundus digitorum. In many cases the removal of the whole phalanx, after the manner above described, is not called for, all that is required being simply to remove the necrosed piece of bone, the joint, as previously explained, often escaping. In this way the periosteum may form a new phalanx, and the finger be comparatively little the worse.

2nd Method—By double Flaps (see Fig. 35, F).—The **assistant** in this case must hold the hand supinated, the finger to be operated upon fully extended, and the other fingers turned into the palm or held aside in any other convenient way. The **operator** standing as before, grasps the tip of the finger between his own forefinger and thumb, and, while keeping the last two phalanges extended, may flex it slightly at the carpo-metacarpal articulation. He then transfixes it as close to the bone as possible, taking care that the back of the knife is just a little way in front (*i.e.*, nearer the tip of the finger) of the crease in the skin corresponding to the joint. A flap of sufficient size is then cut, and is held out of the way by the assistant. The phalanx is next to be over-extended, the joint opened, the knife passed through between the bones, and a small flap cut from the dorsal aspect. Provided he makes the palmar flap of sufficient length, the operator need not make a dorsal flap at all.

3rd Method.—By Circular Incision.—This plan may be adopted when there is not enough sound material left to form flaps. The finger may be conveniently **held** as in the first method, only it must be kept extended. The **operator** standing as before, makes a circular incision about half-an-inch nearer the tip of the finger than the joint. The structures are then to be reflected to the level of the articulation, the ligaments divided, and the bone removed.

A very excellent method is to make anterior and posterior semilunar flaps of sufficient length by dissection.

THE SECOND PHALANGES.

The **second phalanges** may be amputated in exactly similar ways. An objection, however, to the amputation of a second phalanx is that we remove the entire attachments of the flexor sublimis and the flexor profundus tendons—the sublimis being attached to the sides of the second phalanges, and the profundus to the base of the terminal phalanx. The broad expansion, however, of the common extensor that covers the back of the first phalanx is left, and forms new attachments, and therefore the stump remains fixed, it is said, in the extended position, being neither ornamental nor useful, but positively in the way. One might, however, on purely anatomical grounds, suppose that it would not be quite so useless, for into this same expansion are inserted the lumbricales (the so-called "*fiddler's muscles*"), and the interossei muscles. Now, the lumbricales act as flexors of the first phalanges and extensors of the other two, while the interossei also act as flexors of the same phalanges, in addition to their more evident actions of abduction and adduction. This is theoretical, and experience alone is competent to decide the question. In the case of a **single** finger, therefore, it has usually been the custom, in circumstances requiring the amputation of a second phalanx, to remove the whole finger; in cases, however, requiring the removal of two or more fingers, it would manifestly be better to leave the first phalanges. Probably, also, in the case of the index finger it had better be left to act as an opponent to the thumb, but on this point Surgeons are not agreed. No doubt, the amputation of a single finger, as usually performed, weakens the grasp of the hand considerably; but there is no reason why the *whole* of the first phalanx should be removed, its base might be preserved, and this would leave the joint intact, and at the same time keep up the full breadth of the hand. Since writing the above, in 1887, I have had many opportunities, at the Edinburgh Royal Infirmary and elsewhere, of testing the correctness of the old teaching on this subject, and I think there can be but little doubt that the old *teachers were* wrong—I mean, laboured under a misapprehension.

I have seen a number of cases now, where the first phalanx, or only a part of it, had been left, and in every case the flexion and extension of the stump were perfect; and not only so, but it added very greatly to the usefulness of the hand, so that even here the rule holds good—"Save as much as possible." There is, however, one condition where, I think, it will always be found better to remove the finger at the metacarpo-phalangeal articulation at once—even when, at first sight, one might be tempted to leave the first phalanx, or even the greater part of the second as well—I mean in cases where the cellular tissue of the finger is much infiltrated with inflammatory material, the result of whitlow, and this even when the tendons, with their sheaths and the bones, are unaffected. Should the finger be left under these conditions the patient will almost certainly return, if he be a working man at any rate, with the request that the finger be removed altogether, as it is useless and always in the way. This is because the tissues as they heal undergo so much contraction, and so much new fibrous tissue is produced, that the finger is rendered rigid in spite of the muscles acting upon it, although, as Mr DUNCAN has pointed out, the tendons and their sheaths, in almost every case, are seen to be quite healthy when a longitudinal section of the finger is made after amputation. In regard to the second phalanx, however, a compromise has been suggested. The hand being held in the same position as in the first method for the removal of a terminal phalanx, the operator makes two short antero-posterior semi-lunar flaps (see Fig. 35, D). The dorsal flap is made by dissection, its length and breadth being each equal to one-half the diameter of the finger. The dorsal flap being completed and retracted, the finger is then transfixed at the base of this flap, the knife passing in front of the phalanx, and a semilunar flap, equal in size to the posterior, cut from the palmar aspect. Both flaps are then retracted slightly, and the bone divided by the bone pliers at a point previously determined. The flaps, if preferred, may both be made by dissection from the lateral aspects of the phalanx. In cases where the whole phalanx is removed, the tendons, both flexor and extensor, should be stitched to the periosteum of the remaining phalanx and to each other, in the hope that they will form new attachments, and give a movable

and useful stump. The rule for finding the joint is the same as in the first phalanx, or the tubercle at the base of the second phalanx may be used as the guide (see Fig. 36, e).

AMPUTATION OF A WHOLE FINGER.

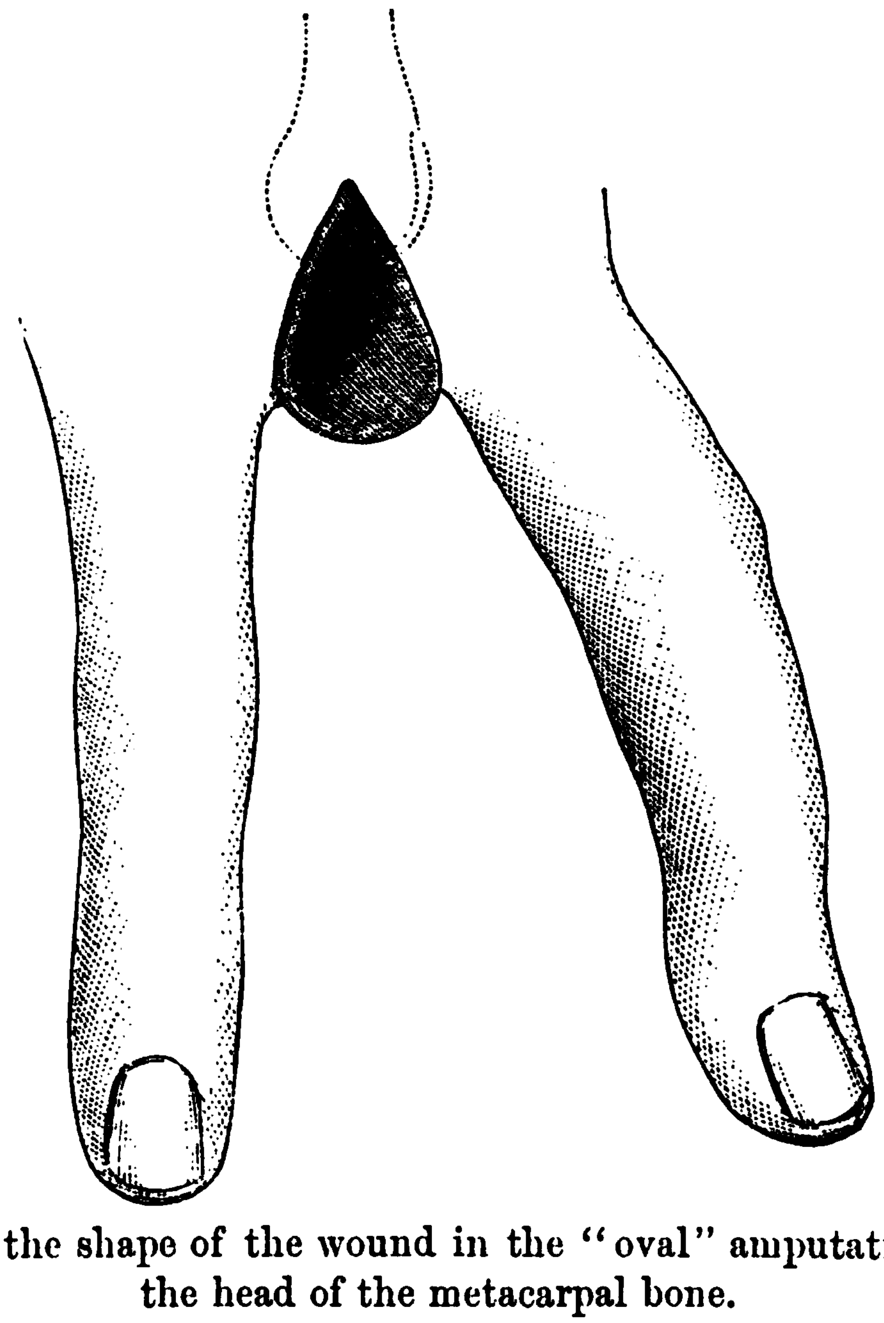
The means to command hæmorrhage, the duties of the assistant, and the position of the operator, are the same as in amputation of a terminal phalanx by the first method. It should be observed that, from the palmar aspect of the hand, the metacarpo-phalangeal joints are fully half-an-inch behind the clefts of the fingers, thus corresponding very closely with the palmar furrow formed by the flexion of the fingers at the metacarpo-phalangeal joints. Note also that, when the hand is clenched, the knuckles are formed by the heads of the metacarpal bones, and that the joint is midway between the posterior surface of the knuckles and the clefts between the fingers.

1st Method—The Oval Operation (Fig. 37).—This method has the advantage that it does not interfere with the palm. The bistoury is entered about half-an-inch behind the head of the metacarpal bone, and after making a short median incision, passes obliquely round the right-hand side of the root of the finger as far as the point of union of the web with the palm, and then across the palmar aspect of the finger in the crease of the skin at its root. Up to this point the knife has not been removed from the wound, but has been gradually laid on from point to heel; but to complete the oval the knife is removed, the left arm and hand of the Surgeon raised well out of the way, and the tip of the finger being amputated so held that now his thumb lies against its palmar aspect—when he commenced the operation his thumb lay on the dorsal aspect. He then re-enters the point of the knife at the end of the median incision on the dorsal aspect of the hand, and the remaining part of the oval is completed as on the other side. This plan is more convenient and neater than the method usually adopted of re-entering the point of the knife on the palmar aspect, and carrying it up from the palm to the dorsal aspect, and completing the oval in that way; further, by the plan above advocated, one is more likely to make the two sides of the oval symmetrical. By the other plan, in making the *second part of the incision*, the Surgeon's right hand with the knife

is over the back of the patient's hand. The skin oval is then to be drawn well back by an assistant, the flexor tendons cut, and the joint opened by the division of the right lateral ligament. The knife is next passed round the base of the bone, and the structures on the other side are divided from within outwards; or the finger may be removed by twisting it round while the edge is pressed against the base of the first phalanx. In the performance of this

Fig. 37.

OVAL AMPUTATION OF FINGER.

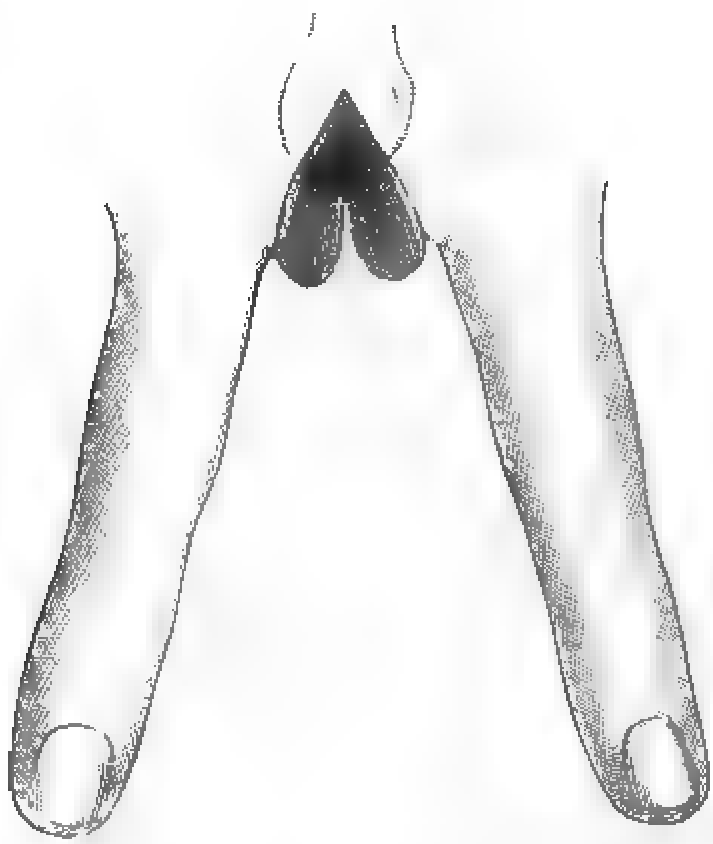


Showing the shape of the wound in the "oval" amputation, with the head of the metacarpal bone.

operation it is of great importance to avoid any injury to the web between the fingers. This is best accomplished by cutting upon the base of the phalanx as the knife passes towards the palm, and in such a way that the centre of the lateral part of the oval may be slightly convex towards the tip of the finger. By doing so the head of the bone is better covered, and there is less cicatricial

contraction of the hand afterwards. If it be intended to remove the head of the metacarpal bone, the incision of the dorsum must be commenced an inch above the head of that bone; in clearing the bone keep the edge of the knife close to it, and do not let the point plunge blindly into the palm, lest a digital artery be wounded at a point very difficult to secure and tie. **Chief Structures divided**—The skin, superficial fascia, digital vessels and nerves, the extensor tendon joined by the lumbrical and interossei muscles, the flexor tendons—sublimis and profundus—in their sheath.

Fig. 38.
FLAP AMPUTATION OF FINGER.



Showing the shape of the wound in the amputation by lateral flaps, with the head of the metacarpal bone.

2nd Method—By Lateral Flaps (Fig. 38).—Two equal lateral flaps are formed from the tissues at the base of the phalanx, the convexity of the flaps being directed towards the tip of the finger. The special advantage of this form is that it provides a free exit for the discharges, but has the disadvantage that it cuts into the palm. ***The assistant*** separates the adjoining fingers as before and pulls

the integument on the back of the hand well up, and then the **operator**, standing in front of the hand, seizes the finger between his own forefinger and thumb and enters the point of the bistoury immediately over the head of the metacarpal bone, and carries the incision, "laying on" the blade as he proceeds, in a convex sweep past the inter-digital web, and ends in the palm at a point just opposite the point at which he started. This forms one flap, and the other may be made in an exactly similar manner; or, after having made the first flap, he may at once open into the joint, pass the knife round the base of the bone and cut the other flap from within outwards. The ligaments and the tendons, etc., being divided, the finger is removed.

3rd Method—By Single Palmar Flap (Professor CHIENE)—(see Fig. 35, C).—In addition to the simplicity of his method, we believe that it more nearly approaches the ideal of what amputation of a finger should be than any other. It fulfils admirably the three essential conditions, viz.—(*a*) To keep up the full breadth of the hand; (*b*) to avoid the remotest approach to a cicatrix in the palm; and (*c*) it also provides a good covering for the head of the metacarpal bone. Before, however, describing the operation, I propose to say a few words on the treatment of the **heads of the metacarpal bones** of the second and third fingers. It is usually admitted now-a-days that in those who labour with their hands (*"workmen"*) they had better be left; but then there comes the difficulty of finding sufficient tissue to cover the head and fill up the ugly gap, and even when the wound is healed (often after tedious granulation), the cicatricial contraction leads to great deformity and much crippling of the hand. It was from considerations such as these, we fancy, more than for any other reason, that in the past it has been so universally advised to remove the head of the metacarpal bone along with the finger. But what is the result? The arch is broken, its powerful connecting transverse ligament divided, the hand becomes squeezed up as if by an incubus it cannot shake off, its free motions are hampered, and its usefulness permanently damaged. It is said, however, that in those who do not labour with their hands (*"gentlemen"*), the head of the bone should be removed, chiefly for the sake of appearance, in order to secure a taper and shapely hand.

Fig. 39.

PROFESSOR CHIENE'S AMPUTATION.

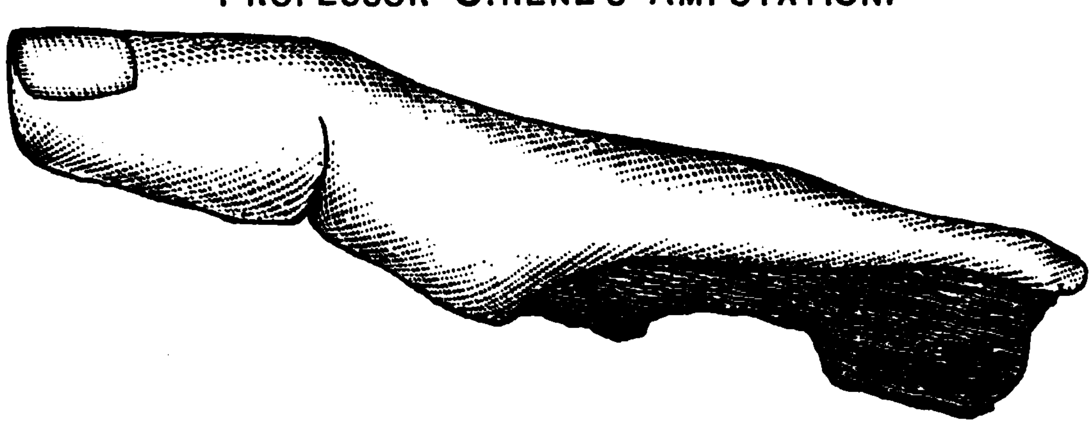
Showing the appearance and position of the Cicatrix.

(From a cast kindly lent by Professor CHIENE.)

In Professor CHIENE's method (see Fig. 35, C), the hand is held in the usual manner, and the point of a sharp bistoury is entered just over the metacarpo-phalangeal articulation, and carried for about *half-way* round the lateral aspects of the root of the finger to be removed. From this point two lateral incisions are made along the sides of the finger parallel with its dorsal surface, and these are next joined by a gently curved transverse incision across the palmar aspect of the finger just through the crease between the first and second phalanges. This flap is then held aside by an assistant; the tendons are cut off short near the base of the flap, and the finger is cleared from its further connections and removed. The flap is then turned up and fixed to the edge of the dorsal wound by a few points of suture. When the wound heals it leaves a neat, horse-shoe-like cicatrix on the dorsal aspect of the hand, well away from the palm (Fig. 39).

Fig. 40.

PROFESSOR CHIENE'S AMPUTATION.



Showing the Finger after Removal.

(From a cast kindly lent by Professor CHIENE.)

THE INDEX AND LITTLE FINGER.

In the case of the **index finger** (see Fig. 35, B), the oval incision, or the "racket-shaped" modification, is to be preferred. The straight part of the incision may be made either on the lateral or dorsal aspect of the hand; in either case the incision is carried forwards to the head of the metacarpal bone, and then the oval made round the root of the finger. The lateral form gives a single lateral linear cicatrix well away from the palm, and also out of sight, and is probably the best form to use in the upper classes; but in workmen the straight part of the incision should be on the

dorsal aspect of the hand, and the side of the oval towards the free surface of the hand should be made larger than the other side, in order that the scar may be placed close to the neighbouring finger. This avoids any scar on the palm or side of the hand, points of great importance to workmen. The **little finger** is treated in exactly the same way, the straight part of the incision being placed on the ulnar side, or the dorsum. Mr Bell, however, in both cases, advises the use of the ordinary lateral flap method, the only difference being that he makes a specially large flap on the free surface of each finger to fold over the end of the bone. In this way there is no cicatrix on the lateral aspects of the hand. As regards the **heads of the metacarpal bones** of the index and little finger, the usual rule is to cut them off obliquely, either with the bone forceps or a small saw, in order to avoid the square, step-like knob which would otherwise remain, and would probably get more than its own share of knocks. But, again, it is advised by some authorities that in the case of a "workman" both should be left. The better plan is, undoubtedly, to remove part of the bone; it is cut off obliquely in such a way that the whole transverse breadth of the head is not removed. By this means the ligamentous connection joining the metacarpal bones of the index and little fingers to the other metacarpal bones is not divided. The **Structures divided** are almost the same as in the other fingers. In the **index** finger, in addition, would be divided the tendon of the extensor indicis, attached to the expansion over the first phalanx, with the dorsalis and radialis indicis arteries. In the **little** finger, in addition to the ordinary structures, the extensor minimi digiti would be divided.

THE THUMB.

No rules can be laid down for amputation of the thumb. In all cases as little should be removed and as much saved as possible, even to half a phalanx. Each of its different segments has a complete set of muscles to command it, and in this respect it differs from a finger; so that whatever is left will ultimately prove useful. In cases where it is absolutely necessary to remove a considerable part of one or more of its bones, it should, if possible, be done subperiosteally, because anything which is under the patient's *control* and opposable to the other digits, is of the greatest possible

value. For the sake of practice on the dead body we will give a short account of what may be styled the **classical** methods of amputating the thumb and its metacarpal bone.

1. **The Flap or V-shaped Method.**—The most convenient position to hold the hand is one midway between pronation and supination, for then it may be pronated or supinated as required, the manipulations differing somewhat on the two sides; the fingers are to be held out of the way by the same assistant. The **Surgeon** may most conveniently, I think, stand in front of the hand. He grasps the tip of the thumb, keeping it extended and slightly adducted, and clearly fixes in his own mind the position of the carpo-metacarpal articulation. **On the left side.**—The knife is entered on the dorsal aspect of the thumb about half-an-inch above the base of the metacarpal bone and then carried obliquely over its ulnar side till it divides the structures forming the web between the index finger and thumb, the point of division being rather nearer the thumb than the index finger. The hand is then supinated, and the thumb bent inwards towards the centre of the palm to relax the muscles forming the ball of the thumb; and the knife, without ever having been withdrawn from the wound, is made to transfix the ball passing close in front of the metacarpal bone, and its point brought out at the first incision at the base of the bone. The thumb is then extended and abducted to render the muscles tense, and the edge of the knife turned towards the skin and a flap cut from the muscles forming the ball, the line of the incision being made to correspond to the dorsal incision, so that when the disarticulation is completed, an elliptical and shapely wound remains. The dorsal flap should now be dissected back a little, the Surgeon himself holding the flap and giving the thumb to the assistant in the meantime, or *vice versâ*. The thumb is now to be over-extended and the joint between it and the trapezium opened, the remaining structures divided, and the digit removed. In making the palmar flap care must be taken not to lock the knife against the sesamoid bones; to avoid this, the direction of the blade must be altered slightly, by turning its edge a little towards the palm, till it has passed these bones. In the final stages of disarticulation, the edge of the knife must be kept close to the bone to avoid injury to the radial, and the radialis indicis arteries.

The Right Thumb is amputated in exactly a similar way, only in this case the Surgeon first makes the palmar flap by transfixion, and then the dorsal one by applying the heel of the knife to the web, and cuts up to the end of the first incision, at the base of the metacarpal bone. He then completes the disarticulation as on the left side.

2. **Oval Method—Racket-shaped Incision** (see Fig. 35, A).—This may be used either for the removal of the thumb at the metacarpo-phalangeal articulation or at the carpo-metacarpal. Begin the straight part of the incision at the base of the metacarpal bone, and carry it along its dorsal aspect (as the hand is held between pronation and supination) to within half-an-inch of the head; from this point an oval is carried round the root of the thumb. The two sides of the incision are then drawn apart by an assistant and the operation completed as in the former method. The **Structures divided.**—In all the operations, the skin, superficial and deep fascia, and superficial vessels and nerves. **Muscles cut** in amputation through the **second** phalanx of the thumb—(1) Flexor longus pollicis, and (2) extensor secundi internodii pollicis. Through the **first** phalanx—(1) Abductor pollicis, (2) flexor brevis pollicis, (3) abductor pollicis, and (4) the extensor primi internodii pollicis, with the previous list as well. Through the **metacarpal** bone—(1) The opponens pollicis, (2) the extensor ossis metacarpi pollicis, and (3) the first dorsal interosseous, with the previous two lists as well. So that in amputation through the **terminal** phalanx, **two** muscles are divided; through the **first** phalanx, **six** muscles; and through the **metacarpal** bone, **nine** muscles.

In amputation through the metacarpal bone the **Arteries cut** are—(1) The princeps pollicis, and (2) the dorsales pollicis. The **Arteries to be avoided** in the same operation are—(1) The radial artery, and (2) the radialis indicis.

Little need be said in regard to amputation of the metacarpal bones of the fingers. Should they require removal for injury no rules can be given. For disease any one may be dissected out by a single dorsal incision. Removal of both metacarpal bone and finger may be most conveniently performed by the "racket-shaped" incision—a straight dorsal incision, and then encircling the root

of the finger by an oval incision. It is advisable, where possible, not to remove the base of the metacarpal bone, as in this way we avoid opening up the carpal articulations. In removal of the index finger with its metacarpal bone the following **Structures are divided**—skin, superficial fascia, etc.; and the following **Muscles**—(1) Flexor carpi radialis; (2) extensor carpi radialis brevior; (3) flexor brevis pollicis; (4) 1st palmar interosseous; (5) 1st dorsal interosseous; (6) 2nd dorsal interosseous; (7) flexor sublimis digitorum; (8) extensor communis digitorum, with its lumbrical muscle; (9) extensor indicis. **Arteries divided**—(1) Dorsalis indicis; (2) metacarpal (first dorsal interosseous); (3) radialis indicis; and (4) part, at least, of first digital from the superficial arch, and probably its communication with the corresponding interosseous from the deep arch.

CHAPTER XIV.

AMPUTATIONS OF THE UPPER EXTREMITY

(Continued).

The Wrist.—The chief object in amputating at the wrist, in preference to higher up the arm, is not so much for the long stump thus left, as to preserve the movements of pronation and supination unimpared. To insure this it is necessary that the inferior radio-ulnar articulation should be healthy; hence, it is no use performing this amputation in cases of disease of the wrist joint, for then the radio-ulnar articulation is almost sure to be implicated, and a better stump will be secured by amputating through the lower third of the fore-arm. It is specially suitable in cases of *injury*. In all the different methods the arm should be emptied of blood by elevation, and the brachial artery secured by an elastic tourniquet or some other means. The **Surgeon** should stand in front of the patient, or on the right side, while the **assistant** stands facing the Surgeon and supporting the fore-arm at a convenient height. The **instruments** required are, a strong-bladed and sharp-pointed knife, artery forceps and ligatures, bone pliers, and a small saw.

1. **Teale's Method** *(Rectangular Flaps)*.—A long posterior flap, composed of *skin and subcutaneous fatty tissue only*, is raised from the back of the hand, its length and breadth being each equal to the circumference of the arm at the wrist joint; the anterior flap is to be one-fourth the length of the posterior, and, like it, to consist only of the integumentary structures. Both flaps are to be carefully raised, doing as little damage as possible to the small subcutaneous vessels. Next, the extensor tendons are divided at *the base* of the posterior flap, and the joint opened; in opening

the joint, remember its peculiar shape—convex, with the convexity upwards. Disarticulation being completed, both flaps are retracted, and the flexor muscles divided evenly at the base of the flaps. During healing, the elbow joint is flexed at a right angle and the fore-arm pronated, as the wound drains best in this position.

2. **Long Anterior and Short Posterior Flaps.**—The **assistant** holds the fore-arm pronated and pulls back the skin as tightly as possible. The **operator** grasps the hand, and, flexing the wrist, makes a semi-lunar incision on the dorsal aspect, from one styloid process to the other, and raises a flap of skin fascia and subcutaneous fat only (BELL)—the flap is to include the tendons of the back of the hand (HEATH). In any case a flap *is* raised and retracted a little above the styloid processes, the extensor tendons rendered tense, and the joint opened. The *palmar flap* may be made by dissection from the outside, before disarticulation, or dissected off the metacarpal bones from above downwards after disarticulation, having previously outlined its edges by a deep incision on each side of the metacarpus. This flap is then retracted, like the posterior, and the flexor tendons rendered tense and divided. It is almost impossible to make the anterior flap by transfixion on account of the transverse metacarpal arch, and the prominence formed by the pisiform bone and the hook of the unciform. The **vessels** requiring ligature are—(1) The radial artery cut close to the radius; (2) the ulnar artery in the palmar flap; (3) sometimes the terminal twigs of the interosseous arteries. The styloid processes are to be cut off with the bone forceps, or the saw if preferred.

3. **The Modified Circular Method.**—The arm is held as in the previous operation (*i.e.*, pronated), the skin at the same time being well retracted, and then two semi-lunar incisions, beginning two inches *below* the styloid processes, are made through the skin, fat, and fascia only, and two short, equal, antero-posterior semi-lunar flaps raised. The flaps are next retracted a little above the level of the styloid processes, and the muscles divided by a circular sweep of the knife at that level, the assistant in the meantime keeping the different groups of muscles tense as the knife passes—*e. g.*, the anterior group by *over-extension (dorsiflexion)*, the posterior group by extreme flexion. The late Mr SPENCE preferred this plan to all others, as, he said, by the ordinary flap method the

styloid processes tended to project at the angles of the incision, whereas by this plan the bones are well covered with sound skin. During healing, the fore-arm is to be kept between pronation and supination.

4. **By Long Palmar Flap.**—An **assistant** holds the arm supinated, and a large square flap, with the angles rounded off, is formed from the palm by dissection. The base of the flap should correspond to the *free edges* of the styloid processes, in order to give a good broad flap; and it should extend fully half-way down the palm, the full width being kept up throughout. It is composed of skin, fat, and fascia, and must be carefully dissected from the palm, avoiding the prominences caused by the ridge of the trapezium and the hook of the unciform; but while avoiding these it is even of more importance to avoid button-holing the flap. Join the two ends of the anterior incision by a slightly curved incision across the dorsum through all the tissues down to the bones. After this, flex the wrist joint forcibly; open it, and detach the hand by dividing the flexor tendons by a single sweep of the knife. The **Palmar Flap** contains—The skin, superficial fascia, fat, and palmar fascia, with the cutaneous vessels and nerves, median and ulnar nerves, superficial palmar arch, and portions of the short muscles of the thumb and little finger. During healing the arm is to be supinated and laid on an elevated pillow, as in this position the wound drains best, and there is less tendency to displacement of the long palmar flap. But if more convenient the fore-arm may be kept midway between pronation and supination.

5. **Circular** (“*triple incision*”).—An **assistant** holds the fore-arm and hand pronated, and pulls up the integuments as tightly as possible. The **Surgeon** stands behind the arm (on the left side), grasps the fingers with his left hand, and makes a circular incision through the skin and subcutaneous fatty tissue, as close to the thenar and hypothenar eminences as possible. The tube of skin is then to be retracted by a few touches of the knife, to the level of the joint, and another circular incision made through the deep fascia and tendons at that level. The joint is then to be opened, the hand removed, and the operation finished by sawing off *the styloid processes*, or snipping them off with the bone forceps.

6. Sometimes it may be necessary to make use of a **Single Long Dorsal Flap,** should the parts in front be hopelessly damaged, or a lateral skin flap, as in DUBRUEIL'S method. In amputation through the wrist joint, the following are the **chief Structures divided**:—1. Integumentary structures. 2. **Muscles**—(*a*) Those towards the anterior aspect—tendons of the flexor carpi radialis, palmaris longus, flexor sublimis and profundus digitorum, flexor longus pollicis, flexor carpi ulnaris; (*b*) those on the posterior or lateral aspect—supinator longus, extensor ossis metacarpi pollicis, extensor primi internodii pollicis, extensores carpi radialis longior and brevior, extensor secundi internodii pollicis, extensor communis digitorum, extensor minimi digiti, extensor indicis, and extensor carpi ulnaris. 3. **Vessels**—(*a*) Radial vessels, with the superficialis volæ branch; (*b*) ulnar vessels. 4. **Nerves**—(*a*) Ulnar, (*b*) radial, and (*c*) median. 5. **Ligaments** of the wrist joint.

LOWER THIRD OF THE FORE-ARM.

In amputating in this situation the objects are—(1) To secure a long stump, and (2) to save the insertion of the pronator radii teres, and thus give the patient more power over any artificial substitute. The **assistant** had better stand in front of the limb, grasping the hand, and hold it either pronated or midway between pronation and supination, as most convenient for the operator The **patient** is brought to the edge of the table, the arm held at right angles to the trunk, and the elbow joint extended. The **instruments** necessary are—A short amputating knife, artery forceps and ligatures, a saw, bone pliers, scissors, and dissecting forceps.

1. **Equal Antero-posterior Flaps.**—The **Surgeon** should stand on the patient's right side of the limb to be removed, *i.e.*, on the outer side of the right limb, but on the inner side of the left. The dorsal flap should be made first by dissection. The fore-arm being pronated, or else held with its dorsal surface towards the operator, he enters the knife a little to the palmar side of the ulna (supposing he is amputating the left arm; on the right arm he would begin by entering the knife a little to the palmar side of the radius) and marks out a broad dorsal flap, almost square, with the angles rounded off, consisting only of the integumentary

structures, the rest of the structures being divided close to the retracted skin. As this flap is being made, the wrist and fingers should be well flexed, and the elbow joint bent. The Surgeon then passes the knife in front of the bones a little below the base of the incision, and cuts an equal palmar flap from within outwards. In forming the anterior flap the forearm should be supinated, the fingers straightened, and the wrist dorsiflexed, and the operator must take care not to pass the knife between the two bones. Each flap should be equal in length to the antero-posterior diameter of the limb at the point of section of the bones, say from two to two and a half inches. The dorsal flap may be raised before or after transfixion, the Surgeon taking hold of it with his left hand and freeing it with a few touches of the knife. Both flaps are then retracted by an assistant, and the bones cleared and divided about an inch higher up. The bones are cleared by a double sweep of the knife round both bones, in the first instance round the under segment and then round the upper, and after this in a figure-of-eight-like way between the two bones, and in doing this it is important not to allow the edge of the knife to be at all directed up the arm, lest the interosseous arteries (especially the anterior) be divided too high up, or split, and retract beyond reach. To avoid this, the rule is always to keep the edge of the knife turned towards the part to be removed. As in all operations of this kind, the large nerve trunks should be shortened with the scissors, to prevent their being included in the cicatrix, causing a "painful stump." Mr SPENCE was in the habit of making the posterior flap a little longer than the anterior, so that it folded over the end of the bone; in this way the cicatrix is not opposite the end of the stump, and the wound drains better. As the bones are nearly of equal size at the point of section, the usual practice is to divide them together. **Vessels requiring ligature** are (1) The radial artery, (2) ulnar artery, (3) anterior interosseous, and (4) posterior interosseous. The radial and ulnar are found in the free end of the palmar flap. The objection to forming the anterior flap by transfixion is that the mass of muscles and tendons protrude beyond the skin; and more especially if the amputation is performed for injury, for then the loosened and bruised tendons yield and are pulled out by the knife and leave

a very ragged and unmanageable surface. Hence, a better result is secured when both are made by dissection, and, as already explained (see page 189), it is better to make the posterior flap about twice the length of the anterior, and to take up a little of the muscular tissue towards its base if deemed necessary: in this way the long flap is made to fold over the ends of the bones, the cicatrix is placed well to the front and less likely to be injured; and further, it drains better, as the limb is to be pronated during the healing process.

2. **By the Modified Circular Method.**—The different steps of this operation resemble very closely the previous one. The arm is held with the hand pronated, and two equal antero-posterior semilunar flaps, consisting of skin and subcutaneous fatty tissue only, are made. The dorsal one is first raised with the same precautions as in the last operation to secure a good, broad base to the flap. A similar flap is next raised from the front; this flap is marked out while the hand is held pronated, by drawing the knife under the limb; the hand is next supinated, and the flap dissected up. Both flaps are then retracted and the muscles divided by a circular sweep of the knife; the bones are then cleared and divided about three-quarters of an inch higher up.

3. **By Teale's Method.**—Take the circumference of the limb at the point of section of the bones and mark out the two flaps according to the rules already laid down (see page 185). Outline the sides of the long dorsal flap by incisions through the integument only, but at its apex carry the knife at once to the bones; this flap must consist of all the structures down to the bones and interosseous membrane. So, likewise, for the short anterior flap. During healing the fore-arm is pronated to keep the long anterior flap more easily in position, and at the same time provide a free exit for the discharges. This method has no special advantage in the arm, because there is no pressure on the end of the stump, as in the lower extremity, and has the disadvantage that the bone must be divided higher up than in equal antero-posterior flaps. TEALE'S amputation in this situation can readily be done by transfixion, instead of the usual plan.

Mr C. HEATH suggests a modification of this method. In this plan the posterior flap consists only of the integumentary structures

until the level of the upper border of the posterior annular ligament is reached, when the knife is carried through everything to the bones. This is to avoid the difficulty experienced in dissecting the tendons from their grooves on the back of the radius and ulna, without damaging them. In Mr HEATH's plan there is also less difference between the length of the two flaps—his anterior being one-third the length of the dorsal, instead of one-fourth, as in Mr TEALE's method.

4. As in other situations, the **Circular "Triple Incision"** may be used. The arm is held at right angles to the trunk, midway between pronation and supination, by an **assistant**, who also forcibly pulls up the integuments. The **operator** may conveniently stand behind the arm on the right side, and between the arm and the trunk on the left side; by so doing he is better able to retract the integumentary sheath, as he then can take hold of it with his left hand.

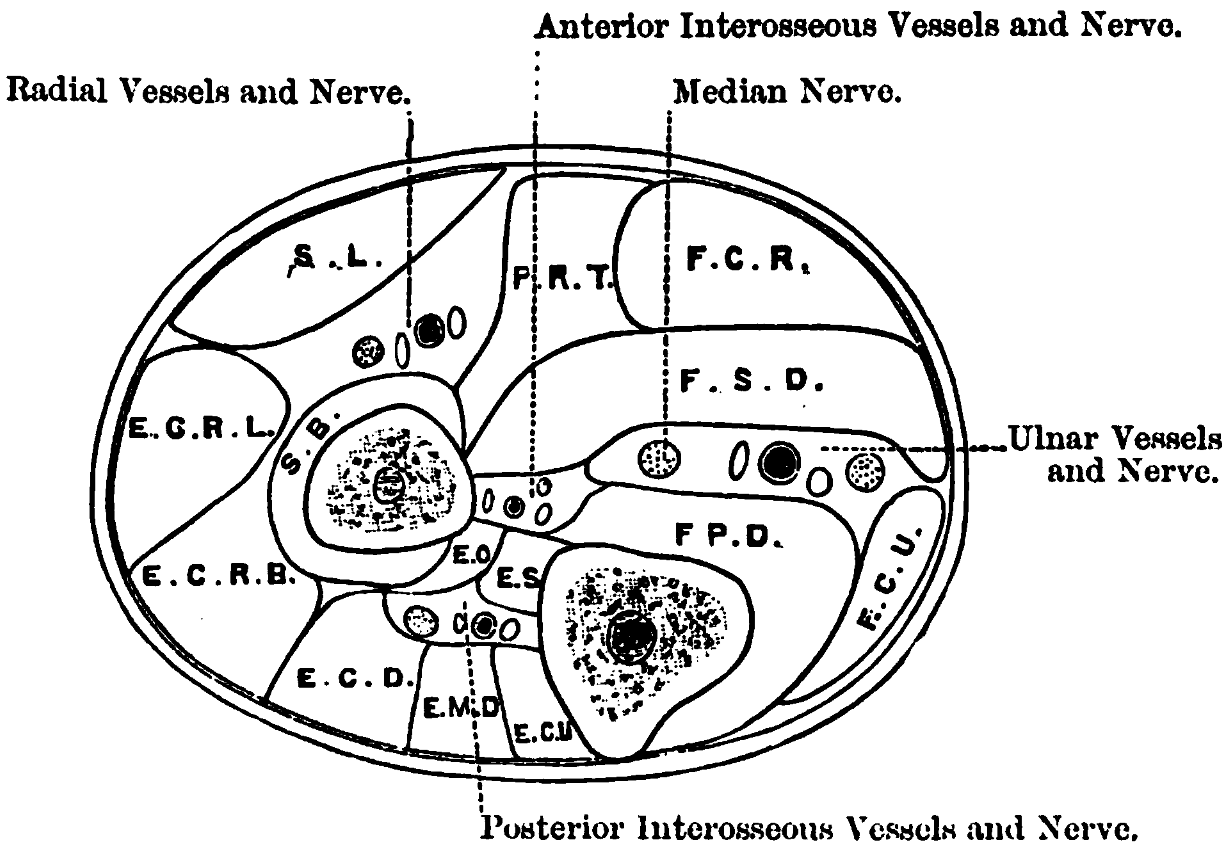
UPPER TWO THIRDS OF THE FORE-ARM.

Amputation may be performed in this situation by—1. **Equal Antero-posterior Flaps, made by Transfixion,** or, better, the dorsal one made by dissection and the anterior by transfixion. 2. **Long Posterior Flap,** chiefly composed of integumentary structures with a little muscular tissue taken up at its base, and an **Anterior Flap** of half the length. 3. The **Modified Circular** method. In making the anterior flap by transfixion, the knife should be brought out rather sharply at the end, in order to keep up the full breadth of the flap, and cut the vessels and nerves transversely. It will thus be square-shaped rather than semi-lunar, and should be about three inches long. If the posterior flap is formed by transfixion, the arm is held between pronation and supination, the soft parts at the sides of the fore-arm are grasped, and as much of them as possible drawn towards the posterior aspect of the limb, so as to secure as broad a flap as possible. For the anterior flap, supinate the fore-arm and enter the knife half-an-inch lower down than the previous transfixion point, to avoid cross-cutting the base of the dorsal flap. The bones are then cleared an inch above the point of transfixion, and divided.

The **Structures divided** in amputations through the fore-arm will vary slightly at the different levels. For instance, at the upper part the pronator radii teres and supinator brevis will be divided, while at the lower part they would not be included; and, near the wrist, the pronator quadratus and the extensor indicis would be cut, but not higher up. To save unnecessary repetition, the following may be taken as a fairly complete general list:—1. Integumentary structures. 2. **Muscles**—(*a*) The pronator teres and flexor carpi radialis, (*b*) palmaris longus, (*c*) flexor sublimis digitorum, (*d*) flexor

Fig. 41.

SECTION THROUGH FORE-ARM.



The names of the Muscles are indicated by their initial letters.

carpi ulnaris, (*e*) flexor profundus digitorum, (*f*) flexor longus pollicis, (*g*) supinator radii longus, (*h*) supinator brevis, (*i*) extensores carpi radialis, longior et brevior, (*j*) extensor communis digitorum, (*k*) extensor minimi digiti, (*l*) extensor carpi ulnaris, (*m*) extensor ossis metacarpi pollicis, and (*n*) extensor secundi internodii pollicis. 3. **Vessels**—(*a*) The radial (in the outer side of the anterior flap, and quite superficial); (*b*) ulnar (in the inner side of the anterior flap, and much deeper); (*c*) anterior interosseous,

and (*d*) posterior interosseous. 4. **Nerves**—correspond to and accompany the arteries—(*a*) The radial, (*b*) ulnar, (*c*) anterior interosseous, (*d*) posterior interosseous, and (*e*) median. 5. Radius and ulna and interosseous membrane (Fig. 41).

AMPUTATION THROUGH THE ELBOW JOINT.

1. This is usually accomplished by cutting a long flap from the anterior aspect of the upper third of the fore-arm and a small one posteriorly. It is seldom performed, because it is rarely possible to get sufficient sound texture to cover the large condyloid end of the humerus; the flaps, further, require to be specially long, because the articular surface of the humerus projects so far beyond the muscular attachments. The upper arm is to be well abducted and held by an **assistant**, the elbow joint flexed almost to a right angle; and at the same time the skin is to be well drawn up, especially when making the posterior incision. The **Surgeon** stands on the right side of the arm on both sides of the body, if he make the flaps by dissection—which is the better method—but if he is to transfix then he stands within the arm, when amputating on the right side; but on the outside when amputating the left arm. The line of articulation of the elbow joint is oblique from without downwards and inwards, and, therefore, the knife must not be passed straight across the arm, or else the operator will find that the tissues will not cover up the internal condyle. The tissues being held well forward by the left hand, the operator then transfixes the limb in a line, extending from a little below the level of the external condyle of the humerus to a point at least an inch below that level on the inner side of the arm. On the left arm the point of the knife is entered at the outer end of this line, but in the right arm it is entered at its inner end. A broad flap, three or four inches in length, is then made, the knife being brought out sharply at the finish, to cut the vessels and nerves transversely, and give the end of the flap a somewhat square form. The flap is held up by an assistant, the fore-arm flexed, and the skin behind drawn tightly up, and the points of transfixion connected behind by a semi-lunar incision through the integumentary structures, so as to form a short flap, and probably also at the same time severing the *connections of* the radius. The ulna is then set free by division of

its ligaments and the triceps muscle. The amputation is a good one in suitable cases, both because of the long stump thus secured, and the bulbous end for the attachment of an artificial substitute.

2. **The Circular Method** may also be used, but it is not so good as the flap. The fore-arm being held supinated, a circular incision is made through the superficial structures, about two inches below the internal condyle. The sheath of skin and fat and fascia is then retracted to the level of the articulation, the joint opened, the remaining structures divided, and the limb removed.

Mr Bryant considers amputation at the elbow an excellent operation, and performs it by anterior and posterior skin flaps, with circular division of the muscles (*i.e.*, the "modified circular"), the posterior flap being the larger, so that the scar may be out of harm's way. The bases of the flaps correspond to the lower extremities of the condyloid ridges.

In this amputation the following are the **chief Structures divided**—1. Integumentary structures. 2. **Muscles**—(*a*) Biceps, (*b*) brachialis anticus, (*c*) pronator radii teres and flexors of the wrist and fingers, including the following muscles—flexor carpi radialis, palmaris longus, flexor sublimis digitorum, flexor carpi ulnaris, flexor profundus digitorum, and flexor longus pollicis; (*d*) triceps and anconeus, (*e*) supinator longus, (*f*) supinator brevis, and (*g*) the following extensors of the wrist and fingers—extensores carpi radialis longior and brevior, extensor communis digitorum, extensor minimi digiti, and extensor carpi ulnaris. 3. **Vessels**—(*a*) Radial artery, (*b*) ulnar artery, (*c*) the common interosseous or its branches, (*d*) posterior ulnar recurrent, (*e*) the corresponding veins, and also the superficial veins of the fore-arm. 4. **Nerves**—(*a*) Median, (*b*) ulnar, (*c*) radial, and (*d*) anterior and posterior interosseous nerves. 5. **Ligaments** of the joint.

AMPUTATION THROUGH THE UPPER ARM.

This is said to be the simplest of all amputations, and may be effected with almost equal success by various methods—as the old circular, modified circular, or by antero-posterior or lateral flaps.

1. **Equal Antero-Posterior Flaps by Transfixion.**—By the use of equal flaps the bone can be divided at the lowest possible point, and the presence of a cicatrix at the end of the stump is not of so

much consequence in the arm; and by making the flaps antero-posterior, associated groups of muscles are kept in separate flaps. The usual **instruments** are required, viz.:—An amputating knife, a saw, artery forceps, ligatures, and bone forceps. An **assistant** holds the arm at right angles to the trunk and rotated well outwards. The brachial artery may be secured by the fingers of another assistant or by an elastic tourniquet; or, if the amputation is high up, the axillary may be compressed against the neck of the scapula by the fingers of an assistant, or by an elastic band; or, lastly, the subclavian may be compressed against the first rib by the thumbs, or a padded key. The brachial artery and the large nerves may be left in the flap the operator deems most convenient, usually the anterior, or at the inner angle of the two flaps; the only point is to take care not to transfix them, and to sever the vessel transversely at last. The **Surgeon** is to stand within the arm in amputating on the left side, but on the outer side for the right arm. He next grasps the anterior muscles with his left hand, and holds them well forward, and then enters the knife with its point directed a little upwards (*i.e.*, the point will be on a higher plane than the handle, which is to be slightly depressed), so as to secure a broad-based flap, passes it as closely in front of the bone as possible, and then, by slightly raising the handle, makes the point emerge at a spot exactly opposite to that at which it entered. The knife is then carried downwards longitudinally for some distance by a slight sawing movement, so as to form a well-rounded flap from two and a half to three inches in length—the skin being cut, if possible, longer than the muscles; for this purpose the knife must be gradually turned towards the surface, but should be brought out sharply at last, so as to cut the vessels, nerves, and skin transversely. An assistant now lightly supports the flap, not retracting it at all, and the knife is then entered half-an-inch below the former point of transfixion, to avoid cross-cutting with the heel, and carried behind the bone and made to emerge on the other side at the same incision, and a posterior flap cut of the same length and shape as the anterior. The assistant now retracts both flaps forcibly, and the bone is raised almost perpendicularly and cleared by circular sweeps of the knife for about an inch and a half above the angles of the *incision*; and, finally, the periosteum is divided by a sweep of the

knife, first round the under segment of the bone and then round the upper, and the saw applied. In clearing the bone, be careful to cut the musculo-spiral nerve cleanly, as it lies in its groove on the posterior surface of the humerus; after the periosteum is divided be careful not to pull back the flaps, lest the periosteum be stripped off the bone. The large nerve trunks should be shortened with the scissors, and the artery, if cut obliquely, may be recut transversely. The **vessels** requiring ligature are—1. The brachial artery, accompanied by the median nerve. 2. The inferior profunda accompanying the ulnar nerve. 3. The superior profunda accompanying the musculo-spiral nerve. Some operators make the anterior flap longer than the posterior. This, no doubt, has several advantages, but they are purchased at the expense of a shorter stump, and, therefore, it should not be performed. It is probably better to raise the anterior flap by dissection, excluding the brachial artery, and then make the posterior by transfixion, at the same time supporting the posterior mass of muscles lightly with the left hand.

2. **Circular Method.**—This may be used in most cases, and is a very suitable method for the lower third of the upper arm, as the bone is so equally covered by muscles on all sides. The arm is held at right angles to the trunk, as usual, and the skin should be well drawn up during the first incision. This may either be entrusted to an assistant, while the operator stands so that he can hold the part to be removed, or the operator himself may so stand that his left hand grasps the arm above the incision and draws up the skin at the same time. The operator now places his right foot well forward, bends both knees, and places his hand and wrist, with the knife, well round the arm, and then traverses the whole circumference of the arm at one sweep, the assistant who has charge of the arm rotating it, so as to meet the heel of the knife. The tube of skin, fat, and fascia is then retracted by the assistant, aided by a few touches of the knife, though the subcutaneous tissue is so loose in this situation that it may be retracted sufficiently by the hand alone. The muscles and fascia are then divided by another circular sweep of the knife at the level of the retracted skin, the knife being held obliquely so as to cut the muscles in the form of a hollow cone, and the bone cleared and sawn at a still higher

level; it is better to divide the biceps first and allow it to retract, and then cut the brachialis anticus by another sweep, as it does not retract so much. In order to retract the tissues more easily and protect them from the saw, a two-tailed calico retractor may be used. As explained elsewhere, the circular method is not to be recommended when amputating through cone-shaped limbs. In this case a far better method is—

3. **The Modified Circular.**—This has already been fully described elsewhere (see page 185). In making the skin flaps, the best rule is to cut just according to your cloth—anywhere and anyway, provided it gives you sufficient healthy tissue to cover the end of the bone. This plan should always be adopted in large muscular arms.

4. **Teale's Method.**—This may be used in certain very exceptional cases. The long flap must be cut from the outer side of the arm, the short one from the inner side, and, as usual, containing the large vessels and nerves. Mr SPENCE used this form of amputation in cases of disease where the muscles of the arm were much atrophied, or the tissues condensed by inflammatory exudation.

5. **By Equal Lateral Flaps.**—The late Professor SPENCE strongly advocated this method when amputating at or near the middle of the arm, on account of the attachment of the deltoid muscle. When external and internal flaps are used, the external one folds over the end of the humerus, when it is raised by the deltoid muscle; but if the flaps are antero-posterior in this situation, when the deltoid raises the arm, the bone is liable to be projected at the external angle of the incision. Observe, in passing, that it is just the reverse in the thigh; there the flaps should be antero-posterior, not lateral, else the bone projects at the anterior angle of the incisions.

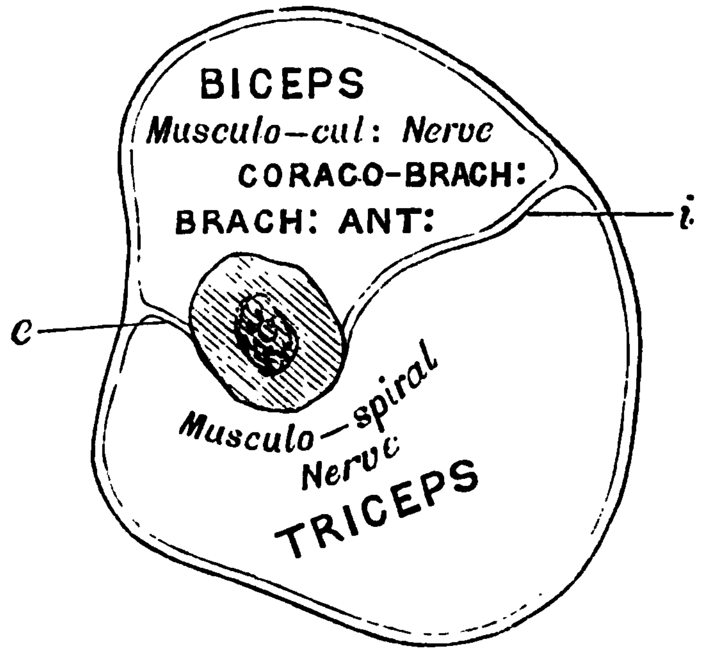
In a general way the **Structures divided** in amputations through the upper arm are—1. Integumentary coverings. 2. **Muscles**—(*a*) Biceps, (*b*) brachialis anticus, (*c*) triceps, and, above the middle of the humerus, the deltoid and coraco-brachialis. 3. **Vessels**—(*a*) Brachial vessels, (*b*) superior profunda vessels, (*c*) basilic vein, (*d*) cephalic vein, and (*e*) inferior profunda vessels. 4. **Nerves**—(*a*) Musculo-cutaneous (between the biceps and the brachialis anticus); (*b*) median (in close relation to and towards the inner side of the brachial vessels); (*c*) ulnar (accompanying the inferior profunda vessels); (*d*) musculo-spiral (accompanying the superior

profunda vessels); and (*c*) internal cutaneous close to the basilic vein. About the middle of the arm the brachial vessels are found on the *inner* side of the humerus; the inferior profunda vessels are found close to the brachial vessels, but a little further back; while the superior profunda vessels are found towards the posterior and outer aspect of the humerus (Figs. 42, 43).

Fig. 42.

SECTION OF FORE-ARM.

(A short way above the middle of the Fore-arm.)

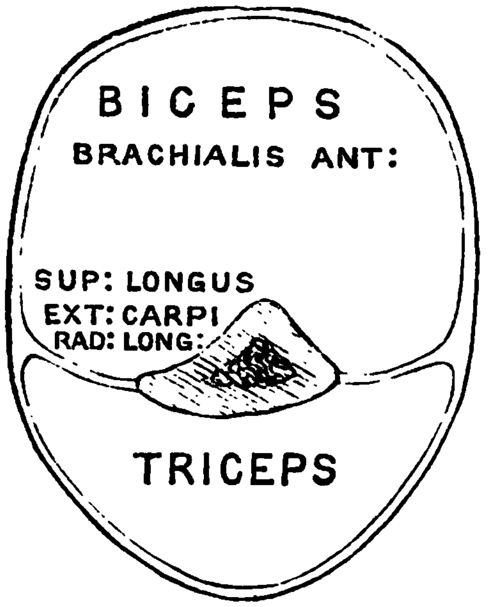


c—External Intermuscular Septum.

Fig. 43.

SECTION OF FORE-ARM.

(A short distance above the Elbow Joint.)



i—Internal Intermuscular Septum.

(From CUNNINGHAM.)

AMPUTATION AT THE SHOULDER JOINT.

This may be rendered necessary by—(1) Disease of the joint and simple tumours; (2) malignant tumours; and (3) injury. In cases where the Surgeon can choose his flaps, the best method to adopt is either that used by Baron LARREY, and associated with his name, or Mr SPENCE's method. Mr SPENCE's amputation is of especial value in cases where there is some doubt as to what is the best course to pursue—whether to excise or amputate. An incision is made as in the operation of excision, the joint examined, and, if found too much disorganised to save, then it is a simple matter to transform it into his amputation. Of course, in the case of both malignant disease and injury, it is impossible to choose the flaps.

In injury, we must take them as best we can from the healthy or least injured tissues, and in malignant disease the usual practice is to form two *skin* flaps from the most healthy-looking parts, taking care not to leave any muscular tissue in them. As in amputation at the hip joint, hæmorrhage is one of the most serious dangers, and, therefore, the principal methods of amputation aim at making the soft parts in the axilla, surrounding the axillary vessels, the last part to be cut through, the artery being previously grasped by the fingers of an assistant. If deemed necessary, the methods described in the operation of excision of the shoulder joint, for the control of hæmorrhage, may also be adopted here.

1. **Lateral Flaps of Nearly Equal Size** *(the "Oval" method).*— This was the method preferred by LARREY. It resembles almost exactly the amputation of a finger by the "oval" method, as described in a previous chapter. The two sides are cut slightly convex, so that, when the operation is finished, the result is two almost precisely similar semi-lunar flaps meeting above at the acromion process, and below at the posterior fold of the axilla— as the tissues on the inner side surrounding the vessels are so cut as to form part of the anterior flap. When the flaps are brought together a straight linear wound is the result. In this amputation two special **assistants** are required—**one**, standing above the shoulder, compresses the subclavian artery with his thumbs or a padded key, and holds himself in readiness to follow the knife behind the humerus and grasp the artery in the tissues at the inner side before they are divided. The **second** assistant places the patient in a proper position, by bringing him well to the edge of the table, so that the part to be removed projects over its edge; he also turns him partially over on the sound side, and supports him in that position by pillows. This assistant then holds the arm for the **operator**, who is to take his stand on the outer aspect of the limb. The arm being held in a position of abduction, the operator thrusts the point of a strong broad bistoury through all the tissues down to the bone, immediately below the acromion process, and makes a straight incision about two inches in length, cutting on the outer aspect of the head and upper part of the neck of the humerus. From the end of this incision he carries other incisions in a curved direction on each side to the corresponding fold of the

axilla. The two semi-lunar flaps thus marked out are next dissected up and held aside so as to expose the joint completely. These flaps should, as far as possible, be separated from the bone by the fingers alone, so as not to injure the vessels on their deep surface. The only vessel of any size divided at this stage of the operation is the posterior circumflex, and this should at once be secured by a pair of WELLS's forceps. The assistant now adducts the arm in order to project and render tense the structures about the tuberosities, rotating inwards and outwards, as may be required, while the operator divides the muscles attached to the tuberosities. The operator then opens the joint, dividing the capsular ligament by cutting on the anatomical neck of the humerus by a semi-circular or horse-shoe-shaped sweep of the knife, as if he intended to cut off the head of the bone at the anatomical neck. The assistant again abducts the arm, and pulls the head of the bone outwards from the glenoid cavity; the knife is then passed round behind it, dividing the remaining part of the capsule, the arm again adducted, and the knife carried down the inner side of the humerus close to the bone, followed by the thumbs of an assistant, who secures the axillary vessels before the tissues are divided. The edge of the knife is now turned towards the surface, and the remaining tissues, between the end of the first and second incision, divided obliquely downwards and inwards, so as to form part of the anterior flap. The **vessels** requiring ligature are—(1) The axillary artery; (2) probably the axillary vein; and (3) branches of the circumflex vessels. The principal **advantages** of this method are—(1) The wound drains well; (2) its cut surface is as small as is consistent with efficient flap covering; and (3) there is less risk of hæmorrhage, during the operation, than in some of the other methods.

RÉSUMÉ of the "Oval" method:—

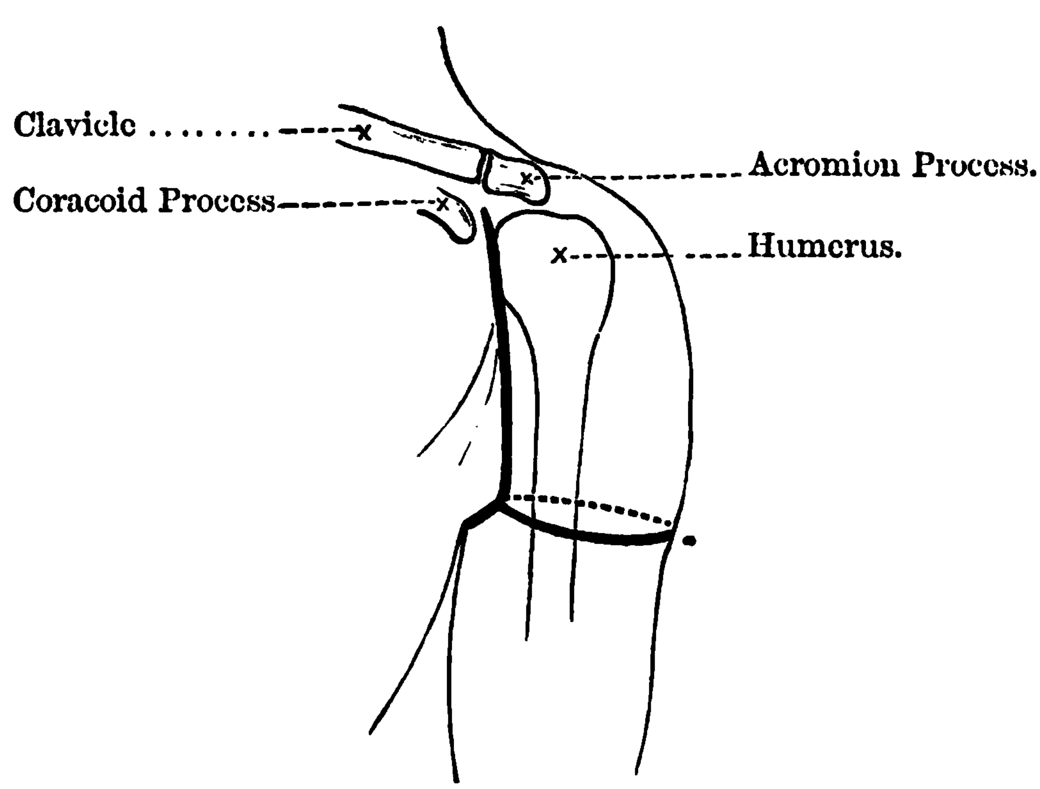
1. Arm held abducted. Make a short vertical incision on the outer aspect of the shoulder, beginning at the acromion.
2. Carry incisions from the end of this short cut to the anterior and posterior folds of the axilla respectively.
3. Reflect these flaps as far as possible.

4. Assistant then rotates the humerus outwards and adducts the arm, while the operator divides the subscapularis tendon and other structures attached to the front of the capsule.
5. Assistant then rotates inwards, and the operator divides the structures attached to the posterior part of the capsule.
6. With the arm still adducted divide the inner and lower part of the capsule, pass the knife to the inner side of the humerus, abduct the arm, and cut downwards, uniting the two former incisions, the vessels being previously compressed by an assistant.

2. **By Large External Flap** (Spence).—Hæmorrhage being provided against in the usual manner, an **assistant** slightly abducts the arm and rotates the humerus outwards. The **Surgeon** then cuts down upon the inner aspect of the head of the humerus, with

Fig. 44.

Spence's Amputation.



a broad strong bistoury, immediately external to the coracoid process, and carries the incision down through the clavicular fibres of the deltoid and pectoralis major muscles as far as the insertion *of the latter* muscle, which is to be divided; this first cut will

divide the anterior circumflex artery, which must be secured at once. The incision is then carried, with a gentle curve, across and deeply through the lower fibres of the deltoid as far as the posterior fold of the axilla (Fig. 44). The course of the inner incision is next outlined from the end of the straight incision to the termination of the curved incision at the posterior border of the axilla, but must extend *through skin and fat only.* The deltoid muscle is next separated from the bone by the fingers alone, so as not to injure the trunk of the circumflex artery which enters its deep surface, and, having done so, the head and upper part of the humerus is fully exposed. The muscles about the head and capsular ligament are next divided by cutting directly down on the anatomical neck of the humerus, the assistant in the meantime rotating the bone so as to bring the various muscles within reach of the knife. The large external flap is then kept out of the way by the fingers of an assistant, or a broad copper spatula, the knife is passed behind the bone, disarticulation completed, and the arm removed by dividing the remaining soft tissues on the axillary aspect, the axillary artery and vein being previously grasped by an assistant; this prevents immediate danger from hæmorrhage, and also avoids the risk of the entrance of air into the vein. In very muscular limbs the skin and subcutaneous tissues should be dissected up for a little way and then the muscles divided at a higher level. The **advantages** of this method are—(1) The fulness and better form of stump left after healing. (2) The posterior circumflex artery is not divided except in its small terminal twigs in front; whereas, both in amputation by the large deltoid flap and the double flap methods, the trunk of the artery is divided in the early stages of the operation often giving rise to considerable hæmorrhage. In the case of the single deltoid flap, the division of this vessel endangers its vitality, as the flap depends chiefly on it for its nourishment. (3) The great ease with which disarticulation can be accomplished, and especially the division of the tendon of the subscapularis muscle. (4) As already mentioned, it is further of great value in cases of doubt as to whether the joint should be excised or amputated. The first part of the incision is made use of to examine the joint, and then the Surgeon acts according to the condition in which he finds it.

RÉSUMÉ.—The **steps** of Mr SPENCE'S operation are :—

1. With the arm abducted and rotated outwards, make a part of the vertical incision, and examine the joint if necessary.
2. Prolong the incision down through the insertion of the pectoralis major, and then curve it across through the lower fibres of the deltoid, towards but not through the posterior border of the axilla.
3. Outline the inner part of the section through skin and fat only.
4. Separate and raise the large deltoid flap with the fingers alone, to avoid injury to the large posterior circumflex artery.
5. The assistant now adducts and rotates, while the Surgeon divides the capsular muscles and the capsule, by cutting on the anatomical neck of the humerus, usually dividing the broad subscapular tendon first.
6. Pass the knife beneath the bone, and keep its edge close to it, divide the rest of the capsule, abduct the arm, and divide the remaining soft parts on the axillary aspect, the vessels being previously grasped by an assistant.
7. Secure the vessels.

3. **Double Flap by Transfixion.**—Both flaps may be made by cutting from within outwards, and are nearly of equal size and gently rounded. Three special **assistants** are required—**one** to take charge of the limb ; a **second** to raise the deltoid flap ; and a **third** to compress the subclavian artery against the first rib, and be prepared to follow the knife behind the humerus and grasp the inner flap, with the vessels, *before* its division. Should the operation be performed on the right side, the **operator** stands before his patient ; if on the left side, he stands behind. The **patient** is brought close to the edge of the table, turned somewhat on the opposite side, and supported in that position by pillows. The assistant then abducts the arm, to relax the deltoid muscle, and may at the same time also rotate the humerus a little inwards. The line of transfixion is from a point an inch in front of the *acromion process*, or midway between the tip of the acromion and

coracoid processes, to another point within the posterior border of the axilla, well behind the root of the acromion and about an inch below the spine of the scapula. On the **right side** the operator enters the knife midway between the acromion and coracoid processes, passes it in front of the capsule of the joint, and makes it emerge at the posterior border of the axilla; on the **left side** he must enter the knife at the posterior border of the axilla, carry it across the front of the joint, and bring it out between the acromion and coracoid processes. In either case before entering the knife it is well to make a small incision about an inch in extent at the point where the knife is to be entered, to avoid cross-cutting the tissues with its heel. Supposing the **right arm** is to be removed, and the patient is placed and the limb held as above indicated, the Surgeon enters the point of a long narrow-bladed transfixion knife midway between the acromion and the coracoid processes, passes it close in front of the capsule of the joint, and brings it out within the posterior fold of the axilla, and cuts a large flap, three or four inches in length, and consisting chiefly of the deltoid muscle; the flap is then to be raised by an assistant standing above the shoulder. The assistant who has charge of the arm then draws it downwards and forwards across the chest, while the Surgeon with the heel of the knife divides the capsular muscles and capsule, close to and against the anatomical neck of the humerus, the assistant meanwhile rotating the bone so as to bring the various muscles within reach of the knife. The head of the bone being turned out of the glenoid cavity, the knife is carried round it and down the inner side of the shaft, for about three inches, with its edge kept close to the bone all the time, and is closely followed by the fingers of another assistant, who grasps the inner flap with the large vessels; when the artery is surely grasped, but not before, the operator cuts obliquely downwards and inwards, forming the internal flap. While this flap is being made the arm is slightly raised and abducted. The **objections** to this method are—(1) To perform the operation satisfactorily we require the leverage of the humerus, but this is often smashed in cases requiring amputation. (2) It is often impossible to find sufficient healthy tissue to form the large external flap. (3) In cases requiring amputation for malignant disease transfixion is out of the question.

Double Flap by Dissection.—In cases where the tissues are thin, it will be necessary, and, indeed, in nearly all cases it is advisable, to form the **deltoid flap by dissection**; the line of the incision will correspond to that already given, extending from the posterior part of the axilla to an inch in front of the acromion process, so as to give a broad-based flap. In operating on the **right side**, the **Surgeon**, provided with a broad bistoury, stands behind the patient. The **assistant** holds the arm well abducted, and the Surgeon commences his incision an inch in front of the acromion process and carries it downwards to the level of the insertion of the deltoid muscle, and then upwards and inwards to a point well behind the acromion, and about an inch below the spine of the scapula, near the posterior fold of the axilla. The flap thus marked out, and which should include the whole deltoid, is then raised, the arm adducted, the joint opened, and the knife passed along the inner side of the bone, the arm again abducted, and the inner flap cut in the usual way with a long narrow-bladed transfixion knife. Should he be amputating the **left arm** he must reverse the proceedings. He stands in front of the patient and commences the incision near the posterior part of the axilla, and ends an inch in front of the acromion process; otherwise the operation is the same as on the right side. In both cases the axillary vessels must be secured before division, either by an assistant, or the Surgeon himself can secure them between the finger and thumb of his left hand.

RÉSUMÉ.—The **steps** of this operation then are:—

1. For the right arm, stand behind; but for the left, stand in front of patient.
2. With the arm abducted, shape and raise the deltoid flap.
3. With the arm adducted, disarticulate by cutting *on* the anatomical neck of humerus, while the assistant rotates the bone to bring the various tendons within reach of the knife.
4. Pass the knife beneath the head of the bone, again abduct the arm and cut an internal flap three or four inches long, securing the vessels before they are divided.
5. *Tie the* vessels.

4. **By Deltoid Flap.**—A large flap consisting nearly of the whole of the deltoid, is raised either by transfixion or dissection, and the different manipulations are nearly the same as in making the external flap in the previous method. The base of the flap will extend from the coracoid process to a little behind the most prominent point, or angle, of the acromion process. Should it be made by transfixion, the arm is to be held in the abducted position in the first instance, to allow the operator to grasp and cut the flap more easily. The flap is raised, and the assistant pushes the arm forcibly across the chest, to make the capsule tense, and rotates the humerus, while the Surgeon severs the capsule and capsular muscles. The head being turned out of the glenoid cavity, the knife is passed round it and the structures in axilla divided, so as to form a short stump of tissues to meet the long deltoid flap which is laid over it. As in the other methods, an assistant grasps the axillary vessels on the inner side, before the tissues are divided. The **objections** to this plan are—(1) The large surface of the wound. (2) The double line of cicatrix. (3) In many cases it would be impossible to get sufficient healthy tissue to form the large deltoid flap.

The principles adopted in amputation through the hip joint might also be applied to the shoulder joint, especially in cases where the Surgeon is short-handed, so far as assistants are concerned. It would leave a longer stump than the other methods, and, were it done subperiosteally, a certain amount of power would be retained to control an artificial limb. The **principles** are—(1) Amputation through the soft parts circularly low down; (2) ligature all the blood-vessels; and (3) dissect out the bone through an incision where it is least thickly covered, and where the blood-vessels are small and few: in the shoulder the incision should, therefore, be along the anterior aspect of the joint and upper part of the shaft of the humerus.

The **chief Structures divided.**—1. Integumentary structures. 2. **Muscles**—(*a*) Deltoid, and the muscles in connection with the capsule of the joint, viz.—(*b*) supra-spinatus, (*c*) infra-spinatus, (*d*) teres minor, (*e*) subscapularis, (*f*) long head of triceps. Muscles not attached to the capsule, (*g*) pectoralis major, (*h*) latissimus dorsi, (*i*) teres major, (*j*) coraco-brachialis, and (*k*) biceps (both heads).

The large **vessels** and **nerves** will be found in the inner flap, and consist of the axillary vessels and the cords of the brachial plexus; in addition to these the cephalic vein and the anterior and posterior circumflex arteries are divided at some stage of the operation, as well as the humeral branch of the acromio-thoracic. The capsular and coraco-humeral ligaments and the costo-coracoid membrane are also cut through.

Amputation of the Scapula and Arm.—In amputations higher than the shoulder joint, as for large tumours of the scapula, *e.g.*, enchondroma, sarcoma, etc., the **chief points** to be attended to are—(1) To divide the clavicle, (2) to divide the muscles attached to the coracoid process (biceps, coraco-brachialis, and pectoralis minor), and then (3) to tie the subclavian, and afterwards proceed to free the scapula, securing the supra-scapular, posterior scapular, and subscapular arteries as soon as possible. The wounded surface is very large, and it is important, therefore, to observe strict antiseptic precautions. The flaps are dorsal and pectoral, semi-lunar in shape, with the convexity directed forwards. The *posterior* begins over the superior border of the scapula, passes down over the acromion process to the lower border of the axilla, and then back to the inferior angle of the scapula; the *anterior* is begun over the clavicle, an inch internal to the coracoid process and carried down over the front of the axilla to its lower border, passing slightly towards the sternum, so as to render its anterior margin somewhat convex. For the **chief Structures divided** in this operation, see "Excision of the Scapula;" only in amputation of the whole upper extremity the muscles and ligaments connecting the scapula and humerus directly are not divided, while the subclavian (or upper part of the axillary), the posterior scapular, and the supra-scapular vessels are divided, as well as the chief branches of the axillary, especially the subscapular and the long thoracic; the pectoralis major is also divided.

RÉSUMÉ of amputations of the Upper Extremity:—In finishing the section on amputations of the upper extremity, I would add a few words to guide the student through the mazes of the very bewildering array of "methods" and "modifications of methods" adopted by various Surgeons.

The following are the methods I would advise on the living body:—

THE HAND.

1. **A Terminal Phalanx.**—A long anterior flap, or antero-posterior semi-lunar flaps.

2. **The Second Phalanges.**—As the terminal; save as much of it as possible, and *do not remove the entire finger*, at the carpo-metacarpal articulation, except in cases of extensive disorganisation from whitlow.

3. **A Whole Finger.**—For the *second and third fingers*, Professor CHIENE's method, leaving the heads of the metacarpal bones. For the *index and little fingers*, the "oval" method, the straight part of the incision being made in the *dorsal* aspect of the hand, the inner part of the oval being longer than the outer, and cut off the projecting *corner* of the metacarpal bones obliquely, but not including the entire breadth of the head.

4. **The Thumb.**—Adopt the method by which you can save most, be it regular or irregular.

THE ARM.

As a general rule, anywhere between the hand and the shoulder, the modified circular, *i.e.*, two equal semi-lunar skin flaps, with circular division of the muscles, may be adopted with advantage; the skin flaps may be taken from any side, and need not necessarily be equal in length, as this would often necessitate a higher amputation than really necessary, especially in cases of smash. Cut the flaps so that their *combined length* will give sufficient covering, and so as to leave the longest possible stump, the position of the scar being of less importance in the upper extremity, provided it is mobile.

1. **The Wrist.**—The modified circular as performed by the late Professor SPENCE, or by the long palmar flap, so as to take a covering from the hard tissue of the heel of the hand.

2. **Lower Third of Fore-arm**—Modified circular, or pure circular.

3. **Upper two Thirds.**—The modified circular, or equal antero-posterior flaps, made by dissection; the method of making the anterior by transfixion is of doubtful advantage, and certainly should never be practised in cases of amputation from injury.

4. **The Elbow Joint.**—By a very long anterior flap with a short posterior, or else the modified circular.

5. **Just above the Elbow.**—The old circular, or equal antero-posterior flaps.

6. **Lower part of Humerus.**—Equal antero-posterior flaps by dissection; the method of making the posterior by transfixion is of doubtful advantage, but may be practised on the dead body.

7. **Just below the Deltoid Insertion.**—Equal *lateral* flaps by dissection; higher than this use equal antero-posterior flaps by dissection.

8. **The Shoulder Joint.**—Mr SPENCE's or the "oval" method (LARREY's). In cases of doubt between excision and amputation, always use Mr SPENCE's method (see "Excision of Shoulder"). The double flap, by dissection, is also a very good method.

CHAPTER XV.

AMPUTATIONS OF THE LOWER EXTREMITY.

The Foot.—Just as in the palm of the hand, it is of primary importance to avoid all approach to a cicatrix on the sole. Therefore, whatever amputations are performed, the flaps must always be taken from the plantar surface. Another point of importance is to leave the heads of the metatarsal bones. The foot is a tripod, resting on the heel, the ball of the great toe, and the ball of the little toe, and only in cases of absolute necessity should this tripod be interfered with in any way; for whether the two anterior rests are narrowed, as in removal of the central metatarsals, or any one of the three removed, the foot is rendered unstable. By a properly shaped boot and well padded stocking any inconvenience likely to result from the prominent heads of the first and fifth metatarsals is easily prevented. In amputations of the toes and metatarsal bones the best **knife** to use is a stout, straight, broad bistoury.

The Toes.—Partial amputation of the toes is but rarely performed, and only in the case of the great toe. In cases where any of the other toes are in a condition necessitating amputation, it is always better to remove them at the metatarso-phalangeal articulation at once; because, if any portion be left, it is apt to be tilted upwards and is positively in the way. Even amputation of the distal phalanx of the great toe is less frequently performed now than formerly. Formerly it was the custom to amputate this phalanx for exostosis—a form of bony growth frequently situated on the dorsal aspect of the distal phalanx of the great toe, giving rise to much pain and discomfort from pressing up the nail. At the present time, however, the treatment adopted is to snip off the exostosis, being especially careful to destroy or remove all the cartilage-covered area, and leave the toe alone. Should it, however,

be necessary from other causes, such as injury, necrosis, onychia maligna, etc., to remove the **terminal phalanx**, this is best accomplished in a manner precisely similar to the analogous operations on the fingers—by the formation of a flap from the plantar surface, the neighbouring toes being pulled to one side and flexed by an assistant by means of strips of narrow bandage.

THE GREAT TOE.

Amputation of the Great Toe at the Metatarso-Phalangeal Articulation.—This may be rendered necessary by injury or joint disease, as suppurating bunion or perforating ulcer, and is best performed by the "oval" or "racket-shaped" forms of incision. It should be borne in mind that the metatarso-phalangeal articulations of all the toes are situated at least three-quarters of an inch above the web. On account of the large size of the head of the metatarsal bone of the great toe the operator must take care to leave plenty of flap to cover it well. An **assistant** should hold the foot extended *(toes pointed)* in the first instance, with the sole resting against, and the toes projecting over, the end of the table; the neighbouring toes are to be held aside and flexed, as already indicated, by narrow bits of bandage. The **operator** then enters the point of a stout bistoury over the middle line of the toe, half-an-inch above the joint, and carries it along the dorsum almost *to the middle of the proximal phalanx*, opposite which point the "oval" part of the incision is carried round the toe. In doing so, the manipulations of the Surgeon and his assistant resemble those in the "oval" amputation of a finger at the corresponding joint. By commencing the "oval" at the point indicated we do not injure the web, and provide ample covering for the large head of the metatarsal bone, and there is thus less likelihood of the wound having to heal by tedious granulation and cicatricial contraction. The tissues over the end of the phalanx and joint are then to be cleared by passing the bistoury round with a short sawing movement, holding it parallel with the phalanx and well under control, and on no account to thrust its point too deeply in the sole, lest the trunk of the *anteria magna hallucis* be injured, or the tissues unnecessarily punctured. After this the toe is to be forcibly

over-extended, the strong flexor tendons cut, and the joint opened from below; the toe is then to be twisted round as the knife divides the lateral ligaments and completes the disarticulation. "The key to easy disarticulation of the toe is complete division of the strong flexor tendons, and to effect this at once I extend the toe forcibly upwards as soon as the incisions in the soft parts are completed; and this enables me to twist the toe so as easily to open the joint and divide the lateral ligaments" (SPENCE). The head of the metatarsal bone should be left, if possible, untouched.

By making the straight part of the incision on the dorsum of the foot we avoid any scar on the lateral aspect, which might prove inconvenient, being irritated and pressed upon by the boot; it is a good plan to make the inner side of the oval larger than the outer, so as to fold over the face of the metatarsal bone. The sesamoid bones may or may not be removed. Should the operator decide to leave them, it may be more convenient to open the joint from above, and divide the flexor tendons afterwards.

In the case of the **other toes** exactly the same principles must be followed, and it is unnecessary, therefore, to go over them in detail. In all cases the oval method is to be preferred. Of course, as in the fingers, it can be done by two small lateral semi-lunar flaps, but this has the disadvantage of opening into the sole. Again, if preferred, in the case of the great and little toes (just as in the case of the index and little fingers), a specially large flap may be taken from the free side of each to fold over the end of the bones.

Amputation of the Great Toe with its Metatarsal Bone.— This should be done by the "racket-shaped" incision. The foot is held as before, and the operator commences the incision on the dorsum, about half-an-inch behind the tarso-metatarsal articulation and carries it along the dorsal aspect to near the metacarpo-phalangeal articulation, from which point the oval is made round the toe. The integuments are then to be separated from the bone on the inner side by applying the knife nearly parallel with the toes, and using it with a short sawing movement, its edge being kept close to the bone and well under control,

especially near the tarso-metatarsal articulation; but lower down it need not be kept so close, as it is better to remove most of the short muscles of the toe and the sesamoid bones (HEATH). The bone is then freed behind by dividing the lateral ligaments on the inner side of the tarso-metatarsal joint, and next by inserting the point of the knife perpendicularly, with its edge directed upwards and backwards, to divide the strong interosseous ligament; and after this the metatarsal bone and toe are drawn forcibly inwards, the anterior end freed completely, and the toe removed. Or the anterior end of the toe may be cleared first, and then its tarso-metatarsal end, by first dividing the strong interosseous ligament between the heads of the first and second metatarsal bones and the anterior extremity of the toe, and the metatarsal bone cleared completely by sweeping the knife under the bone from without inwards. The toe is then forcibly drawn away from the others, and the point of the knife passed between the metatarsal bones, with its edge directed upwards (*i.e.*, towards the anterior aspect of the leg), and the ligaments of the tarso-metatarsal articulation divided close to the metatarsal bone of the great toe, against which the edge of the knife is to be directed, lest the communicating branch of the dorsalis pedis artery, as it passes down to complete the plantar arch, be injured. In cases of *partial* excision of the metatarsal bone and toe the communicating branch from the dorsalis pedis is apt to be *wounded*, and gives rise then to very serious and troublesome hæmorrhage, as it is exceedingly difficult to secure the vessel. In such circumstances Mr SPENCE advises complete removal of the bone, when there will be no difficulty in seeing and tying the artery.

The straight part of the "racket-shaped" incision may be made on the lateral aspect of the foot, the disadvantage being that the scar is apt to be irritated by the pressure of the boot. The method of removing the great toe and metatarsal bone as above described, by the "oval" method, is not so rapid perhaps as the method of lateral flap by transfixion, but has the immense advantage of avoiding any scar in the sole. In the flap method, the Surgeon seizes the soft tissues on the inner side of the foot with his left hand and pulls them well inwards, and transfixes opposite

the tarso-metatarsal articulation, and cuts a flap from the inner side as far as the middle of the first phalanx, keeping as close to the bone as possible. The assistant then pulls the soft tissues as far outwards as possible, so as to bring the incision over the space between the first and second metatarsal bones, and the Surgeon passes his knife between the bones through his former incision, cuts forwards right through the web, and then opens the tarso-metatarsal articulation as in the oval method, and completes the disarticulation. A similar flap may also be raised by dissection. As in the hand, it may be desirable not to open up the tarso-metatarsal articulations, but in the case of the great toe this is not of so much importance, as it has a synovial membrane all to itself; and, besides, it is usually in cases of partial amputation of this bone that trouble is apt to arise on account of wound of the communicating branch of the dorsalis pedis artery. In partial amputations the bone should be divided obliquely, to avoid any unseemly and troublesome projection. A probable advantage is the preservation of the insertion of the peroneus longus and tibialis anticus muscles.

Amputation of the Little Toe with its Metatarsal Bone.—This may be done by precisely the same methods—1. The "racket-shaped" incision, with the straight part of the incision on the dorsum of the foot—the best method. 2. The same incision, with the straight part along the side of the foot—objection, the lateral scar. 3. External flap, either by transfixion or dissection—very bad on account of the scar on the sole. The first form is the best, and is conducted on the same lines as the corresponding operation on the big toe.

Partial Amputation of the metacarpal bone of the little toe has fewer objections, and has more to recommend it, than the corresponding operation on the great toe—1. It has not a special synovial membrane to itself, but one common to it and the fourth metatarsal bone. 2. There is no special artery in danger of being wounded. 3. It preserves the insertion of the peroneus brevis and tertius tendons. Be careful, as usual, to divide the bone obliquely.

The **chief Structures divided** in the foregoing amputations:—In **all** the operations—The skin, superficial fascia, plantar fascia,

digital vessels and nerves, and ligaments of the joints. The following **muscles** are divided in amputation of the **Great Toe**:—At **second phalanx, two** muscles—(1) Extensor proprius hallucis, and (2) flexor longus hallucis. At **first phalanx,** the above two muscles and in addition other **five**—(1) Abductor hallucis, (2) flexor brevis hallucis, (3) adductor hallucis, (4) transversus pedis, and (5) extensor brevis digitorum. At **tarso-metatarsal articulation,** the above seven muscles and other **three**—(1) The tibialis anticus, (2) peroneus longus, and (3) the first dorsal interosseous. So in amputation through the second phalanx, **two** muscles are divided; through the first phalanx, **seven** muscles; and both phalanges with the metatarsal, **ten** muscles. The **Arteries divided** are—(1) Dorsalis hallucis, and (2) the trunk or branches of the arteria magna hallucis. The **Arteries to be avoided** are—(1) The branch of the dorsalis pedis, and (2) the plantar communicating arch.

In amputation of the **Little Toe** with its metatarsal bone, the following **fourteen** muscles are divided:—Into the **metatarsal bone,** *six* muscles—(1) The peroneus brevis, (2) peroneus tertius, (3) flexor brevis minimi digiti, (4) transversus pedis, (5) fourth dorsal interosseous, and (6) third plantar interosseous. Into the **first phalanx,** *four* muscles—(1) The abductor minimi digiti, (2) flexor brevis minimi digiti, (3) third plantar interosseous, and (4) fourth lumbricalis. Into the **second phalanx,** *two* muscles—(1) The extensor longus digitorum, and (2) flexor brevis digitorum. Into the **third phalanx,** *two* muscles—(1) The extensor longus digitorum, and (2) the flexor longus digitorum.

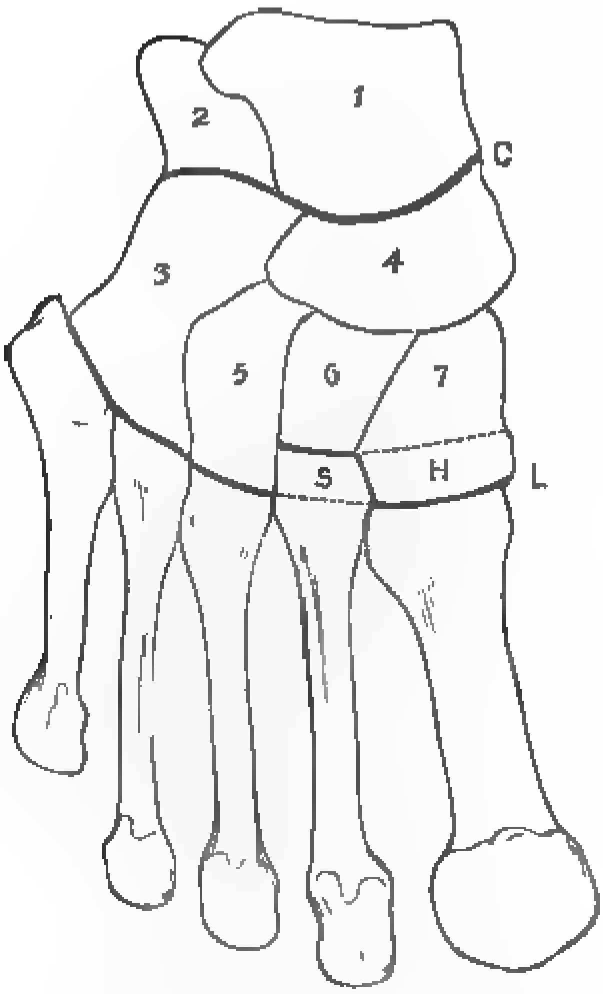
TARSO-METATARSAL ARTICULATION.

Amputation of the Foot at the Tarso-Metatarsal Articulation (see Fig. 40).—This is commonly called "Hey's amputation." Disarticulation of the metatarsus is performed as far as the internal cuneiform bone, and then the projecting part of that bone sawn off (H)—but *not* with a "Hey's" saw, as the facetious examiner sometimes leads the unsuspecting candidate to believe and state. The disarticulation requires to be accomplished with care, as the end of the second metatarsal bone, in its articulation with the middle cuneiform, projects backwards between the external and internal cuneiforms. Lisfranc's modification of this operation

consists in the complete disarticulation of the tarsal bones, leaving the projecting part of the internal cuneiform. The reason for this modification is the supposed advantage gained by leaving the whole of the internal cuneiform bone, to which the tendons of both the tibialis anticus and the tibialis posticus are partially attached. But even in Hey's operation the attachments of these muscles are

Fig. 45.

TARSUS AND METATARSUS.



1. Astragalus.
2. Os Calcis.
3. Cuboid.
4. Scaphoid.
5. External Cuneiform.
6. Middle Cuneiform.
7. Internal Cuneiform.

C. Line of Chopart's Amputation.

L. Line of Lisfranc's Amputation.

S. Part of the Second Metatarsal removed by Skey.

H. Part of the Internal Cuneiform removed by Hey.

Note. — The sigmoid curve formed by the line of Chopart's amputation; also the mortise formed by the three cuneiform bones, into which the base of the second metatarsal juts.

not destroyed; for, although anatomists figure certain points on *bones* as the attachments of the muscles in question, yet it is found practically that they have extensive attachments to the deep ligamentous structures in their neighbourhood; so that this disadvantage, as urged against Hey's operation, is more imaginary than real. Another objection urged against Hey's amputation is that a cancellous bone is divided, and that there is therefore a

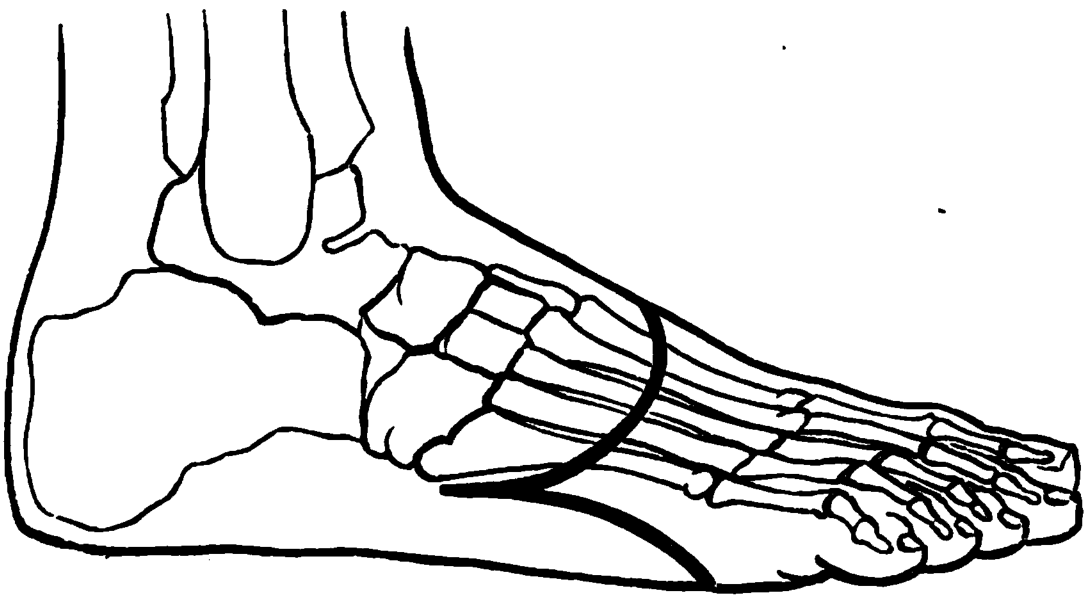
greater risk of septic absorption and osteo-myelitis. HEY's amputation, however, is more easily performed and leaves a better stump than LISFRANC'S. Mr SKEY removes the end of the second metatarsal bone, but does not interfere with the internal cuneiform.

The amputation may be performed in one of three ways:—In the **first**, the dorsal flap is made first, the bones disarticulated, and the plantar flap cut afterwards. In the **second**, the plantar flap is cut first, then the dorsal, and after this disarticulation performed. In the **third**, the dorsal flap is first made, as in the first method, the plantar flap is then shaped and dissected up as in the second method, and lastly the bones are disarticulated. In the **first** plan the leg is placed with the foot downwards, the ankle joint fully extended, and the **assistant** keeps the heel firmly fixed upon the table with the part of the foot to be removed overhanging its edge, and at the same time pulls the skin tightly upwards. The **operator** then grasps the toes firmly, keeping the ankle joint well extended, and when the dorsal flap is outlined by the first incision, the assistant retracts it while the Surgeon frees it by a few touches of the knife; he then disarticulates, and finally forms the plantar flap. In the **second** form the **assistant** grasps the toes, and holds the foot at right angles to the leg with the heel firmly pressed against the table, while the **operator** dissects up the plantar flap; the dorsal flap is next made as in first plan, the assistant holding the foot as there described, and the operator grasping the toes and extending the ankle joint. In the **third** plan, the foot is held as in the first stage of the first method (well extended, and the Surgeon grasping the toes); it is next held as in the first stage of the second method (at right angles, and the toes grasped by an assistant), and then disarticulation performed in a manner common to all the three. A strong, sharp, stout-backed, sharp-pointed, and not too broad-bladed bistoury is the best **knife** to use; the blade should be about four inches long, but the point must not be too spear-like lest it break off in opening the joints. The **guides** for this operation are (Fig. 46):—The projection formed by the fifth metatarsal bone on the outer side, and the tarso-metatarsal articulation of the great toe on the inner side, a groove corresponding to which may be felt by firm pressure, or, if this is indistinct, a point may be taken one inch in front of the tubercle of the scaphoid, which will indicate the articulation

nearly enough for all practical purposes. It is often a little difficult to find the tubercle of the scaphoid with certainty. First of all find the internal malleolus, then pass forwards and slightly downwards and the next prominence met with is the head of the astragalus, about one inch from the malleolus; then, still passing in the same direction, comes the tubercle of the scaphoid, about one inch further forward, lastly, and about another inch in front of this, is the articulation of the first metatarsal bone with the internal cuneiform. The beginner is apt to mistake the head of the astragalus for the tubercle of the scaphoid.

Fig. 46.

Incisions for Hey's Amputation.

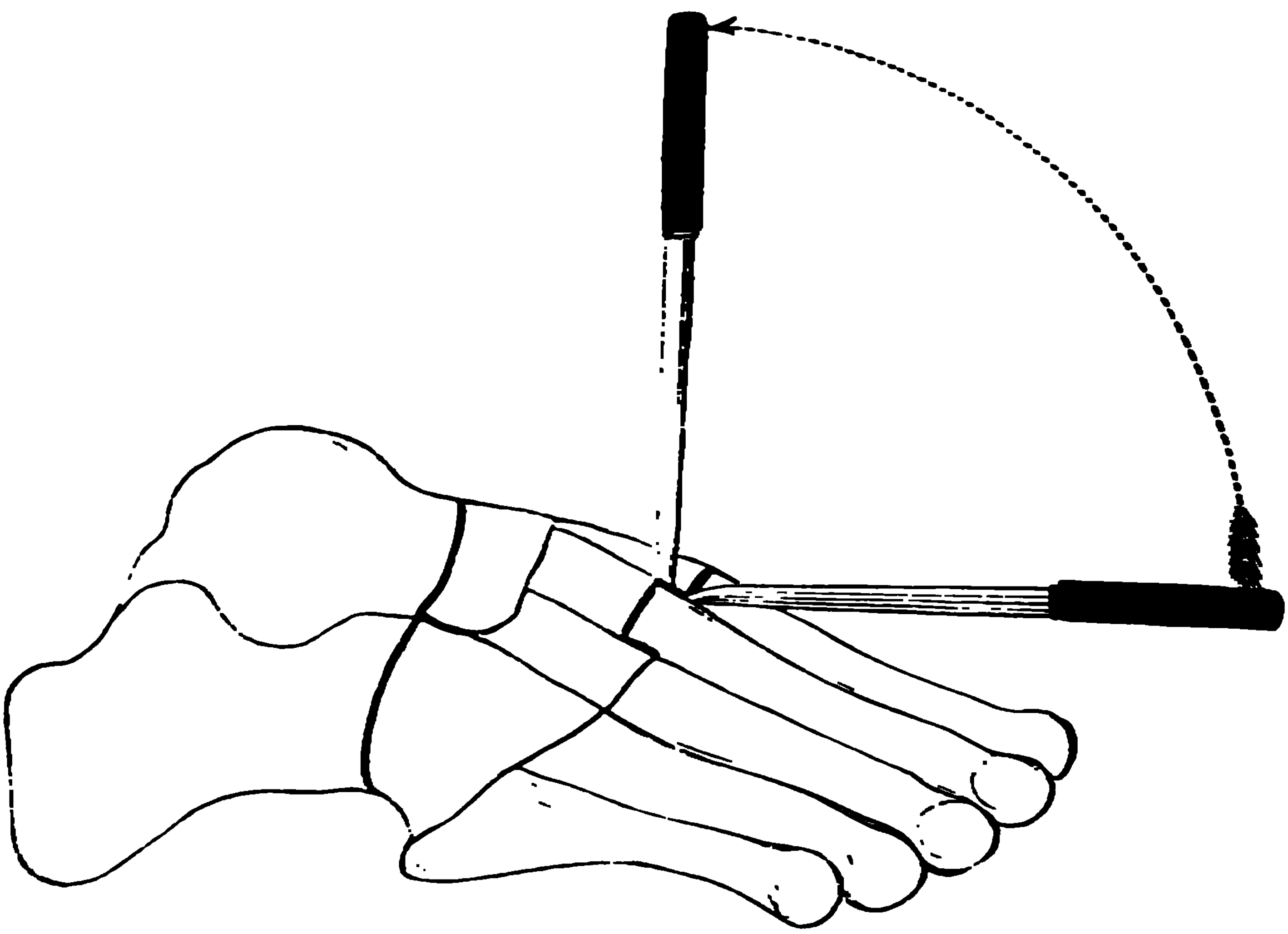


In amputating by the **first** method the Surgeon seizes the toes with his left hand, extends the ankle joint well, and places his forefinger and thumb on the points marking the line of the articulations—one well behind the projection of the fifth metatarsal bone, and the other over the metatarsal bone of the great toe. He then makes a semi-lunar incision, down to the bones, beginning and ending half-an-inch in front of the bony guides, forming a short semi-lunar flap, "down nearly to the heads of the metatarsal bones" (Heath). The incision should commence and end fairly in the sole. The assistant then seizes the end of the flap to retract it, while the Surgeon by a few sweeps of the knife dissects it up, taking care to keep the edge of the knife towards the bones. The articulations are then to be opened (see Fig. 45).

on the right side they are to be opened from the fifth inwards till the knife is arrested by the second metatarsal bone; the knife is then taken out and the articulation between the first metatarsal bone and the internal cuneiform opened: in opening the joints the operator should work only with the point of the knife, and confine himself to the division of ligaments. The Surgeon inserts the point of the knife obliquely between the bones, with

Fig. 47.

LISFRANC'S AMPUTATION.



To show the method of freeing the second metatarsal bone from the mortise formed by the cuneiform bones.

its edge uppermost, and gradually raises it to the perpendicular (Fig. 47), and then presses firmly backwards between the bases of the first and second metatarsal bones and moves it gently backwards and forwards until he feels the strong interosseous ligament snap. The same may be done if necessary to the other side, and also between its base and the middle cuneiform, the toes at the same time being firmly depressed, and then, by giving a smart wrench the disarticulation is completed. He then places his left

thumb over the end of the disarticulated bones and dissects off a flap, consisting of the whole thickness of the tissues of the sole, and carries the dissection as far as the roots of the toes. From the layer of tissues thus dissected up, the operator shapes a neatly-rounded flap, longer on the inner than on the outer side, by transfixing the centre and cutting towards each side, and so sloping the knife that the integumentary structures are cut longer than the muscles.

RÉSUMÉ of LISFRANC'S method :—

1. Foot extended, and the bony guides felt by index finger and thumb.
2. Outline the dorsal flap, beginning and ending half-an-inch in front of the bony guides; and divide the tendons by a second cut near the base of the skin flap, so that they may not project beyond the skin.
3. Make the plantar flap by carrying two lateral incisions along the sides of the foot, and join by a curved incision in front across the sole, but obliquely, so that the flap is longer on the *inner* side.
4. Assistant then holds foot at right angles while this flap is being raised.
5. Then disarticulate, remembering the mortise into which the second metatarsal juts.

Instead of this method, the whole operation may be done as described in the *résumé* of CHOPART. On the living body, Mr SPENCE always performed HEY'S method, as it was easier and left a better stump.

By the **second** method the plantar flap is cut first. A straight incision is carried from the two bony guides along each side of the foot, reaching nearly to the roots of the toes and the inner one longer than the outer; the two lines are then united in front by a gently curved incision, thus marking out a flap with well rounded angles. The flap is then raised, and at first should consist only of integumentary and fascial structures, but after the first inch, may include everything down to the bones. A dorsal flap is next to be made as in the previous method, the joints opened, and the bones disarticulated.

The **third** plan (see *résumé*) is probably the best. The dorsal flap is formed as in the *first* method; next the plantar is shaped and dissected up, as at the beginning of the *second* method; and finally the bones are disarticulated.

The **vessels requiring ligature** are—(1) The dorsalis pedis at the apex of the dorsal flap, (2) internal plantar, (3) external plantar, and (4) numerous branches of the plantar arch and dorsal plexus of veins. By making the short dorsal flap the cicatrix is placed rather on the front of the stump, and is thus opposed to the soft padding; whereas, were it on the dorsum, it might be injured by the pressure of the boot.

The **objections** to the tarso-metatarsal amputation (HEY, or LISFRANC), as thus described, are—1. If practised in a *diseased* foot, probably the other bones and joints will also be diseased and lead to a return of the mischief. 2. If for *accident*, it is far too elaborate and complicated, and more especially as the anterior parts of the foot are smashed, and therefore we have no advantage of leverage to assist in disarticulation; a simpler and better way being simply to dissect back a sufficient sole flap, and then saw the bones across at any convenient point, irrespective of articulations. This plan has further a special advantage, as it may leave the front of the foot a little longer, which will thus form a more effective lever to oppose the tendo achillis.

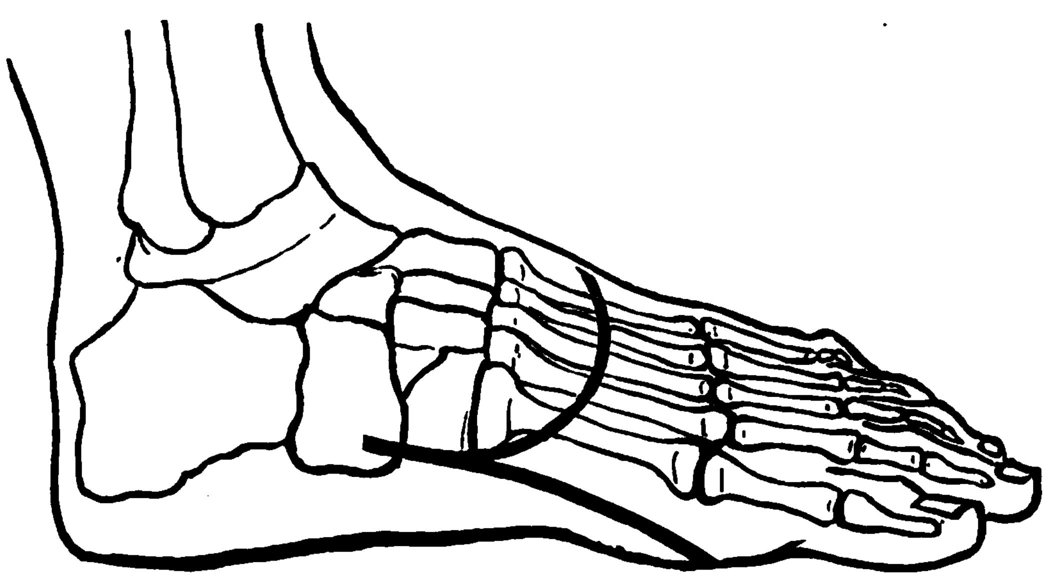
MEDIAN TARSAL ARTICULATION.

Chopart's Amputation (Fig. 45 C).—This operation consists in the amputation of the foot at its transverse articulation—*i.e.*, the articulations between the astragalus and the scaphoid on the inner side, the cuboid and the os calcis on the outer side; in other words, the removal of that part of the foot that lies in front of the os calcis and astragalus. The shape of the articulation is alternately concave and convex—on the *inner* side it is *convex* forwards (due to the rounded head of the astragalus), but *concave* forwards on the *outer* side. The manipulations of the Surgeon, the duties of the assistant, and the three methods of raising the flaps, resemble very closely the corresponding stages of the previous operation, so that they need not be repeated in detail.

The **guides** for this operation are the tubercle of the scaphoid on the inner side, and a point one inch behind the projecting base of the fifth metatarsal bone on the outer side; or, in fat ankles, a point midway between the projecting base of the fifth metatarsal bone and the front of the external malleolus (Fig. 48). The **knife** used by CHOPART was about six inches long, half-an-inch broad, sharp-pointed, and stout-backed. Suppose the operation is to be performed by the **third** method, the **Surgeon** places his thumb and forefinger on the two bony points already indicated, and fully extends the ankle joint, and then makes a semi-lunar incision down to the bone, marking out a flap about an inch and a half

Fig. 48.

INCISIONS FOR CHOPART'S AMPUTATION.



in length, commencing and ending well in the sole, and half-an-inch in front of the bony guides. The **assistant** retracts this flap as the Surgeon frees it by a few touches of the knife. This being done, the assistant next seizes the toes and holds the foot at right angles to the leg and pressed firmly against the table, while the operator forms the plantar flap by cutting along the sides of the foot as far as the "tread," and joining the two side incisions by a gently curved one in front, but taking care that it leaves the flap much longer on the inner than the outer side, as the inner edge of the foot is much deeper; the flap should be somewhat square-shaped, with well rounded angles. When the flap is fully dissected down, the foot is again extended, the bones disarticulated, and the

operation completed by sawing off the projecting head of the astragalus and the articular surface of the os calcis.

The **objections** to this operation are—1. If done for *disease*, it leaves two bones of all others the most likely to be diseased. 2. If for *injury*, it is better to dissect up a sufficient flap from the sole and saw the bones at the most convenient point, irrespective of articulations. 3. The muscles forming the tendo achillis have nothing to counteract them and therefore draw up the heel, and the patient soon begins to walk on the front part of his stump, *i.e.*, on the cicatrix, more especially in cases of amputation for disease. For this reason it is advisable, in cases where this amputation is performed, to divide the tendo achillis subcutaneously at the same time, in order to equalise matters. The tendency to tilting, however, may be obviated, to a great extent, by stitching the extensor and flexor tendons together over the face of the stump. SYME's amputation at the ankle joint is to be preferred to either HEY or CHOPART in the case of disease of the bones, and for CHOPART in almost every condition.

RÉSUMÉ of CHOPART's amputation :—

1. Foot extended and bony guides felt by thumb and index finger.
2. Outline dorsal flap, beginning and ending a little in front of bony guides.
3. Retract skin flap and then divide everything down to bones at base of flap.
4. Bend foot forcibly downwards and disarticulate.
5. Then peel off all the structures forming the sole, keeping the knife close to the bones, as far as the balls of the toes.
6. The flap is then fashioned and dressed, being cut longer on the inner side. Lateral incisions might be first made, as in LISFRANC, and the whole operation completed as there described (see *résumé* of LISFRANC). In every case it is probably better to shape and raise the plantar flap by dissection, before disarticulation, both in HEY and CHOPART.

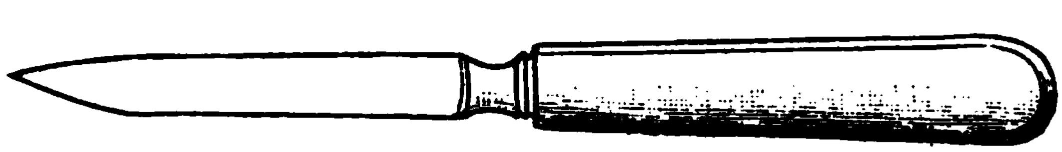
Chief Structures divided in the two preceding Operations.—1. The integumentary coverings and the plantar fascia. 2. **Muscles**—(*a*) Tibialis anticus and extensor brevis digitorum; (*b*) the extensor communis digitorum and the peroneus tertius; (*c*) the extensor proprius hallucis; (*d*) the peroneus longus and brevis; (*e*) the tibialis posticus; (*f*) the first layer of muscles of the sole of the foot (the flexor brevis digitorum, abductor hallucis, and abductor minimi digiti); (*g*) the second layer of muscles (the tendons of the flexor longus digitorum and flexor longus hallucis, accessorius and lumbricales); (*h*) the most of the muscles of the third layer (flexor brevis hallucis, adductor hallucis, flexor brevis minimi digiti, and transversus pedis). 3. **Vessels**—(*a*) The internal plantar artery; (*b*) the external plantar artery, with the plantar arch and its digital branches; (*c*) the dorsal artery of the foot, with its tarsal and metatarsal branches. 4. **Nerves**—(*a*) Anterior tibial or its branches; (*b*) the plantar nerves; (*c*) digital branches of the musculo-cutaneous or peroneal nerve; (*d*) the digital branch of the external saphenous nerve. 5. The **Ligaments** of the various joints opened into; and, further, we may specially mention the long and the short plantar ligaments and the inferior calcaneo-scaphoid. The structures divided in HEY's operation are almost the same as the above, with the following exceptions:—The tibialis anticus and posticus and the flexor accessorius are not divided, and part of the internal cuneiform bone is removed. In LISFRANC's operation this bone is not divided.

THE ANKLE JOINT.

1. **Syme's Method.**—As in all amputations of the foot, the tibial arteries are to be secured by the thumb and fingers of an

Fig. 49.

KNIFE FOR SYME'S AMPUTATION AT THE ANKLE JOINT.



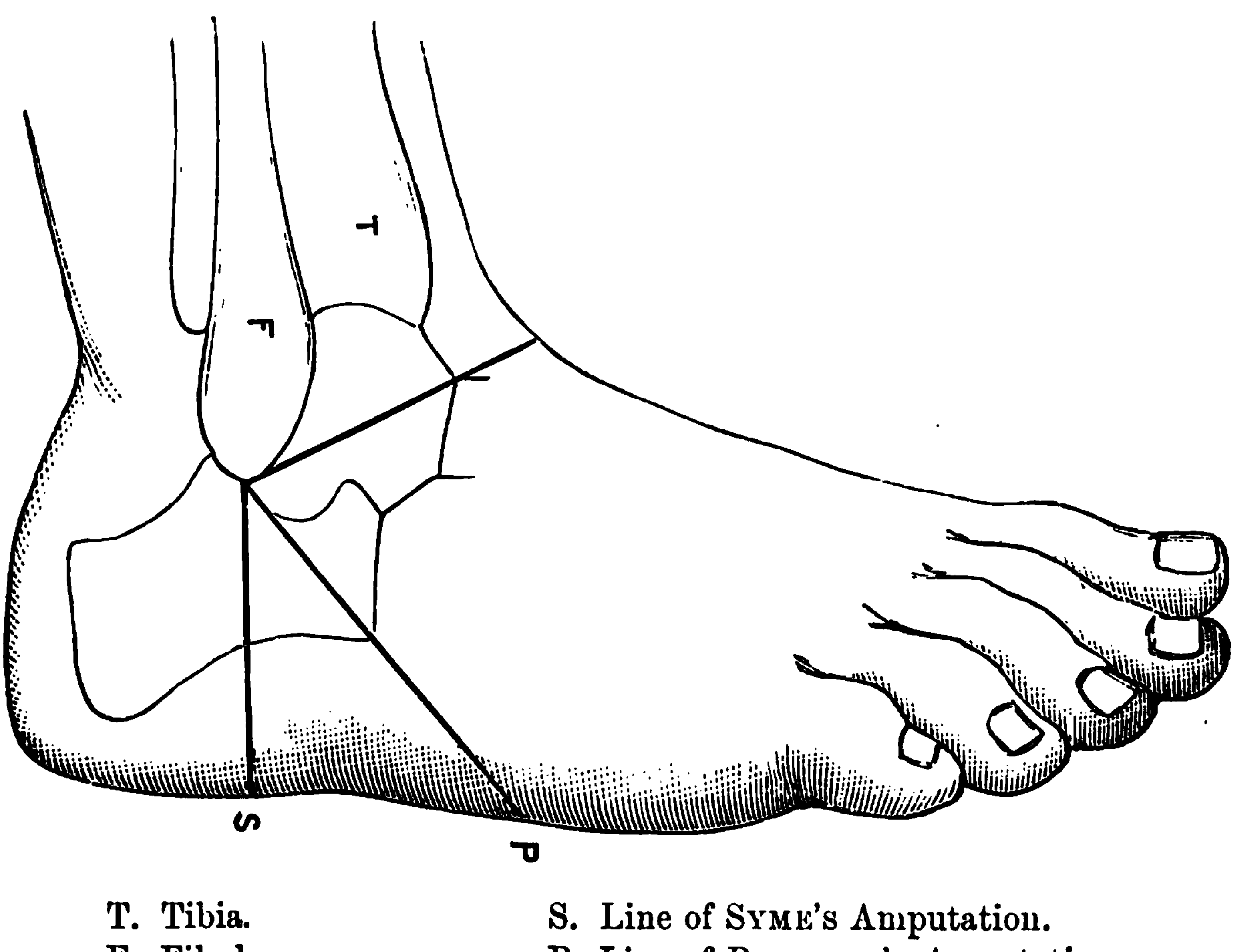
assistant—the thumb being pressed over the anterior tibial at a point midway between the two malleoli, the fingers over the

posterior tibial about half-an-inch behind the internal malleolus —or else by an elastic tourniquet applied above the ankle joint, or at the lower third of the thigh.

An **assistant** grasps the toes and holds the foot at right angles to the leg with the heel projecting over the edge of the table, or over a block, while the operator is making the heel flap. The only **instruments** required are an ordinary saw,

Fig. 50.

OUTER SIDE OF RIGHT ANKLE.



T. Tibia.
F. Fibula.
S. Line of SYME's Amputation.
P. Line of PIROGOFF's Amputation.

Note the relation of the incisions to the external malleolus.

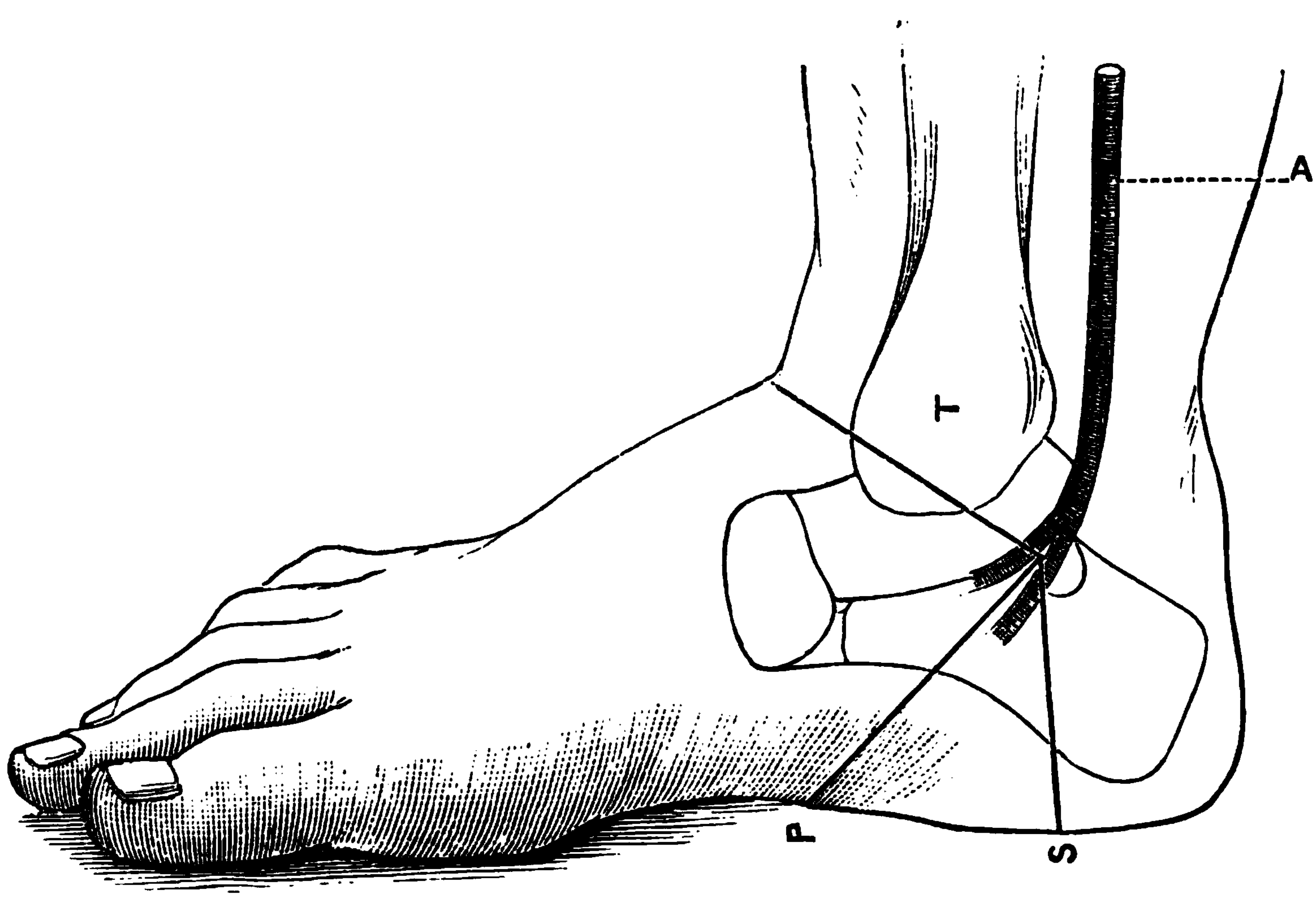
probably a lion forceps, artery forceps, ligatures and scissors, and a knife; the blade of the knife should not exceed four inches in length, and it should have a strong back as well as a large and strong handle (Fig. 49). The **guides** for this operation are —the external malleolus on the outer side, a point rather nearer its posterior than anterior edge, and a point *exactly opposite this* on the inner side, *i.e.*, a point about half-an-inch behind

and below the internal malleolus, as the external malleolus is longer than the internal and also posterior to it (Figs. 50, 51, S).

Position of the Patient.—In this, as in all amputations of the leg and thigh, he should be brought well down towards the lower end of the operating table, his sound leg being tied to one of the

Fig. 51.

INNER SIDE OF RIGHT ANKLE.



A. Posterior Tibial Artery. S. Line of SYME's Amputation.
T. Tibia. P. Line of PIROGOFF's Amputation.

Note the relation of the angle, formed by the two parts of SYME's incision, to the internal malleolus—below and behind; also that the posterior tibial artery is divided in this angle, just after its division into the two plantar arteries.

legs of the table. The foot being held as directed, the **Surgeon** takes his place facing the foot, and grasps the heel with the palm of his left hand, and places his thumb and forefinger on the two points already named, and then carries an incision from the one to the other across the sole, inclining slightly backwards, cutting down to the plantar fascia and bone at once—the point of bone cut down

upon should be the large internal tubercle of the os calcis; the heel flap should contain no muscular tissue. Should the flap extend in front of the tubercles, great difficulty will be experienced in dissecting it back over the os calcis. In raising the heel flap the operator places the fingers of his left hand behind the os calcis (or rather below, as the foot is now held) and inserts the point of his thumb between the edges of the plantar incision. In the dissection he must keep the edge of the knife close to and parallel with the bone, guiding it with his thumb nail till the os calcis is fairly turned and the insertion of the tendo achillis comes into view. The nail not only guides the knife, but pushes the flap downwards, and also prevents the edge "scoring the flap." The operator then grasps the front part of the foot with his left hand, fully extends the ankle joint, and unites the two ends of his first incision by another across the front of the ankle "forming an angle of 45° to the sole of the foot and long axis of the leg" (SYME), in other words, he cuts as straight as possible across the front of the ankle, dividing all the tendons, vessels, and nerves. Mr HEATH directs it to be made at right angles to the first. Mr SYME, we believe, made this incision immediately after he made the plantar one, and therefore before the heel flap was dissected back, and this is the method still followed in the Edinburgh School. The anterior flap is then to be seized by the assistant and drawn slightly upwards, while the operator frees it a little if necessary. The ankle joint is then opened from the front, and the lateral ligaments on each side divided by the point of the knife being carried outwards and downwards on each side between the malleoli and the astragalus; the joint is best opened by a horse-shoe shaped incision with the convexity upwards, and not in the direction of the primary incision, as this avoids locking the knife against, and sawing on the neck of the astragalus. In disarticulating, the operator must be careful not to injure the posterior tibial artery, as it lies in a groove on the posterior surface of the astragalus. The foot can now be dislocated forwards, and is pressed downwards, while the tissues behind the os calcis are divided with the edge of the knife kept close to the bone, and the removal of the foot completed by the division of the tendo achillis. It should be stated that some *Surgeons* form the heel flap from above, after making the anterior

cut, as they say it avoids the tedious dissection of the heel flap round the projecting os calcis, as in the other method. The knife is then to be carried round the tibia and fibula to prepare them for the saw, while the assistant retracts the flap; the external malleolus is next to be grasped with lion forceps, and then both malleoli are sawn off, including a thin slice of the intervening part of the tibia —just enough to include all the cartilage-covered surface. The saw must be kept parallel with the lower end of the tibia, that is to say, at right angles to the axis of the limb, the blade neither being allowed to cut obliquely in the antero-posterior direction, nor yet from side to side. Both in clearing the bone and in sawing it, the operator must again be careful of the posterior tibial artery, and also the vessels that lie behind the two malleoli—the continuation of the peroneal behind the external malleolus, and a branch of the posterior tibial behind the internal. In dissecting the heel flap by keeping the knife *close to the bone* we avoid making button holes, and also "scoring" the flap, which is especially objectionable, as it severs large numbers of fine vessels on which the nutrition of the heel flap chiefly depends, and which form long anastomosing loops nearer the bone than the skin, and running chiefly in the antero-posterior direction (as looked at in the position of amputation). These important anastomosing loops are derived from two lateral arteries of some size running along each side of the heel flap; the outer one is the continuation of the peroneal artery, while the inner one is derived from the posterior tibial artery about one inch above the ankle joint. When the incisions are made according to Mr Syme's directions the posterior tibial artery is not cut till after its division into internal and external plantars; the point of section is just in the angle where the two incisions meet on the inner side (see Fig. 51). Some difficulty may be experienced in stitching the hard edge of the heel flap to the thin skin in front of the stump. Before stitching up the wound it is necessary to secure every vessel that can be seen, as well as the dorsalis pedis (or the termination of the anterior tibial) and the two plantar vessels, to avoid as far as possible any general oozing.

As regards **drainage** we can either make a *longitudinal* slit in the lowest part (as the patient lies in bed) of the heel flap, so that

any scar will not be on the surface on which he is to walk; or, perhaps the better and more usually adopted plan, is to pass a drainage tube through the stump transversely, bringing its ends out at the angles where the two incisions meet. This latter plan is amply sufficient, especially if the patient be taught to lie for some time on the affected side with the amputated limb flexed at the knee and in front of the sound leg, so that the discharges may escape at the fibular angle; and at the same time we may, by properly applied cotton wool and bandages, prevent any cavity forming in which the discharges can accumulate. Should all go well the tube may be safely removed in a few days. It will be observed that the general rule, about making a short posterior flap so as to facilitate drainage, is broken in this amputation, because the heel flap, thus secured, bears pressure so much better than an anterior flap would. If the plantar incision is made from malleolus to malleolus the flap is not symmetrical, and the incision in the sole extends too far forwards, which makes it very difficult to turn back the flap over the prominence of the heel; and very likely before this is accomplished, irreparable injury has been inflicted on the heel flap. PIRRIE saws through the tibia and fibula without disarticulating at all.

RÉSUMÉ of SYME's amputation :—

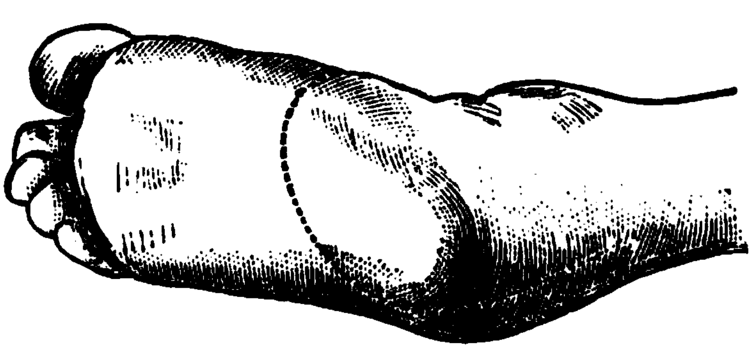
1. Foot held at right angles by assistant, and sole cut made.
2. Foot extended by Surgeon, and the cut in front of the ankle made.
3. The assistant again holds the foot at right angles, while the Surgeon raises the heel flap till the prominence of the os calcis is turned and the tendo achillis visible.
4. Open the joint by a horse-shoe cut, convexity upwards, divide the lateral ligaments, and detach, taking care of the posterior tibial artery, as it lies on the astragalus behind.
5. Clear the ends of the tibia and fibula and saw, again taking care of the posterior tibial artery.
6. Examine the inferior tibio-fibular articulation and gouge it out if necessary: after this tie the vessels, close the wound, drain, dress, and apply a splint.

2. **Mackenzie's Method—By a Large Internal Flap** (also called "Roux's amputation").—The foot to be amputated is laid on its outer side and firmly held by an **assistant**, with the foot and ankle projecting over the edge of the table or over a block of convenient height. The **guides** for this operation are not bony but tendinous, viz., the tendo achillis behind and the tendon of the tibialis anticus in front, at the level of the ankle joint. The **Surgeon** then places his thumb and forefinger on the two tendons, at the level of the ankle joint—the tendo achillis behind, and the tendon of the tibialis anticus in front, almost over the centre of the

MACKENZIE'S AMPUTATION.

(After SPENCE.)

Fig. 52.



Large Internal Flap.

Fig. 53.

Incision on Outer Side.

joint. He then inserts the point of the knife over the centre of the tendo achillis, and cuts obliquely across that tendon towards the outer and plantar aspect of the heel, along which it is continued for a little way in a semi-lunar direction, and is then curved upwards in front of the internal malleolus, till it crosses the tendon of the tibialis anticus, about an inch in front of the inner malleolus; it is better, I think, to take as much of the hard heel tissue as possible in this flap, and its base to be on a level with the internal malleolus, and as broad as possible. Another incision is then made, without removing the knife from the wound, by carrying it across the outer aspect of the ankle, forming a semi-lunar flap, uniting the two ends of the first incision; the convexity of the flap should be about an inch below the

ankle. The flaps are then to be dissected up, taking care of the posterior tibial and plantar arteries, which are found in the centre of the large internal flap; in order to preserve these vessels it is necessary to go down to the bone *at once*, and dissect up muscles and all in one mass. Disarticulation is then performed, the tibia and fibula cleared and sawn as in SYME's amputation, and with the same precautions.

The **advantages** claimed for this method are—1. It can be performed in cases where the tissues on the outer side of the foot have been destroyed by disease or accident. 2. When the patient lies on his side the large internal flap is kept in good position by its own weight. 3. There is a free exit for discharges, etc., from the posterior and outer side, so that there is less risk of pain and tension and putrefaction of the accumulated discharges. 4. There is no risk of sloughing, as the posterior tibial and the two plantar arteries are in the centre of the flap. It is a curious fact that the stump in this amputation in a very short time comes to resemble the stump in SYME's amputation so closely that it is almost impossible to tell the one from the other.

3. **Pirogoff's Method.**—The peculiar feature of this amputation is the preservation of the posterior part of the os calcis in the heel flap, which is adjusted to the cut surface of the tibia and fibula. The foot is held at right angles to the leg, and the incision begins and ends at the same points as in Mr SYME's amputation (see Figs. 50, 51, P), but is not made directly across the foot, as in that method, but should be carried obliquely forwards, so that the centre of the incision in the sole is an inch and a half in front of a line drawn transversely across the sole from the tip of one malleolus to the other, or a little beyond the anterior end of the os calcis. The incision must go down to the bone obliquely, and, therefore, the blade of the knife must not be held at right angles to the sole. The edge of the flap may then be freed from the bone for about half-an-inch; the foot is next to be extended, and a *straight* cut is made across the front of the ankle joint uniting the two ends of the first incision. Disarticulation is next performed, as in SYME's amputation, by opening the thin anterior ligament of the ankle joint and then dividing the strong *lateral ligaments*, with the point of the knife inserted between

the malleoli and the astragalus. The foot is still further extended, and the fatty tissue in front of the tendo achillis cleared, exposing the posterior part of the upper surface of the os calcis; the bone is also more fully cleared in the line of the first incision. The operator then draws the foot well downwards, its sole resting on the table or overhanging its edge, while the assistant grasps and steadies the heel. A narrow saw with a movable back (but an ordinary saw will do well enough) is then applied midway between the astragalus and the tendo achillis, and a section made through the os calcis obliquely downwards and forwards in the line of the first incision. If the foot is held overhanging the edge of the table, or a block, during this part of the operation, the section will seem almost vertical. He next removes a slice from the end of the tibia and fibula, transversely and at right angles to the axis of the bone, as in SYME's amputation. The osseous surfaces are then to be accurately adjusted, and the limb laid on its outer side with the knee joint flexed, so as to relax the muscles forming the tendo achillis, and thus avoid tilting the part of the os calcis in the heel flap. The *oblique* section through the os calcis is to insure that the dense tissues covering its *lower* part are exactly at the end of the stump, and will receive the weight of the body; further, it exposes a larger surface of bone to apply against the cut ends of the tibia and fibula, and the retained part of the os calcis does not require to be tilted so much on its own axis in order to adhere closely to the tibia and fibula, and has, therefore, less tendency to be displaced by the tendo achillis. Should, however, the tendency to tilting be great, the tendo achillis may be divided, or the bones may be "wired" together. Originally, PIROGOFF used a vertical cut through the os calcis, merely preserving the projecting posterior end. This, of course, necessitated a greater dissection of the heel flap, which had to be reflected a little beyond the line of the ankle joint; further, when healed, the part supporting the patient's weight was rather the thin posterior layer of tissue, instead of the hard heel pad from the sole.

The **advantages** claimed for this method are—1. It leaves a longer stump. 2. It is more easy of performance than a SYME, as it saves the tedious and difficult dissection of the heel flap, but the bones require more accurate adjustment. 3. There is

less liability to sloughing of the heel flap, as the vascular supply is less disturbed. 4. It is said to bear pressure better. Its **disadvantages** are—1. Return of the disease in the fragment of bone left in the heel flap, and therefore this method should never be chosen in the case of disease of the bones of the ankle joint. 2. Greater liability to osteo-phlebitis and pyæmia, owing to the section of the two spongy bones. 3. The process of union and consolidation of the bony surfaces is more tedious. Lastly, as compared with SYME's amputation it is not *better* fitted to support the weight of the body, nor *so well* adapted for progression (SPENCE).

Subastragaloid Amputation (LIGNORELLES).—Removal of the foot below the astragalus through the joint between it and the os calcis. The **guides** for this operation are:—A point three-quarters of an inch below the external malleolus, and opposite the outer tubercle of the os calcis, on the outer side, and the tuberosity of the scaphoid on the inner side. A heel flap is made somewhat after the manner of SYME's amputation, but extending rather further forwards, and a dorsal flap as in CHOPART's amputation, the anterior bones removed as in that operation and the os calcis dissected out afterwards, first opening the joint between the scaphoid and astragalus, and then that between the astragalus and the os calcis. Commencing on the outer side (right foot) the incision is carried forwards for a little way, and then downwards to the sole of the foot, passing just behind the prominence of the fifth metatarsal bone, across the sole and brought up to the tubercle of the scaphoid on the inner side. The ends of this incision are connected by another curved incision across the dorsum of the foot. The soft parts are next raised on the outer side sufficiently to reach the tendo achillis, which is to be cautiously divided. The finger is now introduced into the wound, to feel for the articulation between the os calcis and the astragalus; the point of the knife is then pushed in between the bones, and the strong interosseous ligament divided, while the foot is wrenched forcibly inwards. The astragalo-scaphoid articulation is next opened, and then the parts on the inner side and the rest of the heel flap are put on the stretch by

twisting the foot, separated from the os calcis, and the foot removed. In cases where the flaps are somewhat scanty, the head of the astragalus may be sawn off. A serious objection to this method is the fact that it leaves a loose bone at the end of the stump over which the patient has no control, and which must of necessity, therefore, cause great insecurity during progression.

Hancock's Amputation.—This consists of amputation below the astragalus, and at the same time leaving the posterior third of the os calcis, which is turned up against the denuded surface of the astragalus. It, therefore, bears the same relation to subastragaloid amputation as that of PIROGOFF does to SYME'S. The **incisions** must extend further forwards than in subastragaloid amputation, passing on the one side to a point half-an-inch anterior to the projecting end of the fifth metatarsal bone, and to a corresponding point on the other. These incisions are then united by a third semi-lunar incision with its convexity towards the toes. The flap thus marked out is to be reflected nearly as far back as the tuberosities on the under surface of the os calcis, and then a fourth incision is carried across the dorsum of the foot, just behind the head of the astragalus. Next, the posterior third of the os calcis is divided by the saw applied to its under surface, the other tarsal bones separated from the astragalus, and the foot detached. The head of the astragalus is sawn off, its inferior articular surfaces denuded by the bone forceps, the vessels tied, the posterior third of the os calcis turned up against the denuded surface, the flaps fixed, and the operation completed. The wound is drained from the lower angles, which are left open.

The alleged **advantages** of this operation are—1. It leaves a longer stump. 2. The greater amount of leverage afforded by the astragalus for the artificial foot. In cases of disease of the tarsal bones it is a doubtful operation, unless one could be quite certain that the retained bones were perfectly healthy; and, as already stated, the astragalus and the os calcis are, of all the bones, the most likely to be diseased.

I ought to mention **Tripier's Amputation** which is said, by TRIPIER, to possess all the advantages of CHOPART without any of its disadvantages. The os calcis is cut horizontally at *right*

angles to the long axis of the leg at the level of the sustentaculum tali, and thus gives a flat surface to stand upon, instead of the posterior part of the os calcis and the unsupported anterior extremity of that bone. The periosteum covering the under surface of the os calcis should be preserved and turned up against the raw section. The skin incisions are made as in CHOPART'S amputation.

The following is a general list of the more important **Structures divided** in the previous amputations in the vicinity of the ankle joint:—1. The integumentary coverings and plantar fascia. 2. **Muscles**—(*a*) The tibialis anticus; (*b*) the extensor communis and brevis digitorum and peroneus tertius; (*c*) the extensor proprius hallucis; (*d*) the peroneus longus and brevis; (*e*) the tendo achillis and plantaris; (*f*) the tibialis posticus; (*g*) the first layer of muscles of the foot (the abductor hallucis, flexor brevis digitorum, and the abductor minimi digiti); and (*h*) part of the second layer (the tendons of the flexor longus digitorum and flexor longus hallucis, and accessorius muscle). 3. **Vessels**—(*a*) The dorsal artery of the foot, or the anterior tibial; (*b*) the internal and external plantar vessels, or else the posterior tibial close to the point where it divides into these vessels; (*c*) the long and the short saphenous veins; (*d*) the external calcaneal branch of the peroneal artery; (*e*) the internal calcaneal of external plantar; and (*f*) also twigs from the tarsal artery, the internal malleolar branches of the posterior tibial, and the malleolar branches of the anterior tibial. 4. **Nerves**—(*a*) The posterior tibial or plantar nerves; (*b*) the anterior tibial; (*c*) the musculo-cutaneous or peroneal; and (*d*) the long and the short saphenous nerves. 5. The ligaments of the ankle joint and the various other joints disarticulated. 6. The ends of the tibia and fibula, and, in PIROGOFF'S amputation, the os calcis, and, in HANCOCK'S amputation, the astragalus as well as the os calcis. Further, in PIROGOFF, as compared with SYME, the tendo achillis is not divided, the first layer of muscles of the sole are divided as well as the flexor accessorius, and the plantar vessels are divided much further forwards.

CHAPTER XVI.

AMPUTATIONS OF THE LOWER EXTREMITY

(Continued).

Amputation just above the Ankle. — In all cases where amputation at the ankle joint cannot be performed, amputation immediately above the ankle should if possible be chosen in preference to that at the "seat of election," for two reasons—1. The longer stump gives greater command over the artificial limb, and instead of, as formerly, using the old "box leg" with the stump projecting behind, the knee being flexed and placed between the prongs, the stump is now encased in the socket of a short wooden pin in the extended position. 2. Amputation in this situation is less fatal than amputation higher up. According to Mr DUNCAN, SYME's heel flap may be used even when the bones are divided two and a half inches above the ankle joint. The main artery is secured above the knee as in the previous operations on the foot, or by the thumbs of an assistant against the ilio-pectineal eminence. The **patient** is brought well down, so that the part to be removed projects over the end of the table, and is held horizontally above the level of the table, with the knee joint slightly flexed, and the foot and leg well inverted, by an **assistant** seated on a low stool, the **Surgeon** standing on the right-hand side of the leg to be amputated. The other leg is secured to a leg of the operating table.

1. **Teale's Method.**—Long anterior and short posterior rectangular flap. (For a description of the principles of this method see page 185.) The chief objection to the method is that the bones are not divided at the lowest possible point, and therefore the stump is not so useful, and there is, also, a greater risk to life. The large square anterior flap may be taken partly from

[illegible] of the leg [illegible] a flat surface [illegible] part of the [illegible] layer. The [illegible] should be [illegible]. The skin [illegible]

The [illegible] is a general [illegible] **Structures divided** [illegible] the [illegible] The [illegible] **Muscles** [illegible] digitorum [illegible] (b) the [illegible] and plantar [illegible] of muscles of the [illegible] ligament, and the [illegible] the second layer (the [illegible] and [illegible] longus hallu- [illegible]

Vessels [illegible] The dorsal artery [illegible] internal and external [illegible] to the point [illegible] and the short [illegible] branch of the peroneal [illegible] external plantar, and (c) [illegible] the [illegible] calcaneal branches of [illegible] branches of the anterior tibial [illegible] plantar nerves; (b) of [illegible] or peroneal [illegible] saphenous nerves. [illegible] [illegible]

... The **vessels requiring ligature** ... tibial at the middle of the apex of the ... posterior tibial and (3) the peroneal artery, ... flaps.

... amputation —

... flaps by the rules already laid down.

... lateral incisions, and then divide all the soft ... to the bone at the apex of the anterior ... anterior flap should be a perfect square.

... flap, using the *handle of the scalpel* ... to separate it from the interosseous mem... ... not to harm the anterior tibial artery.

... the posterior flap.

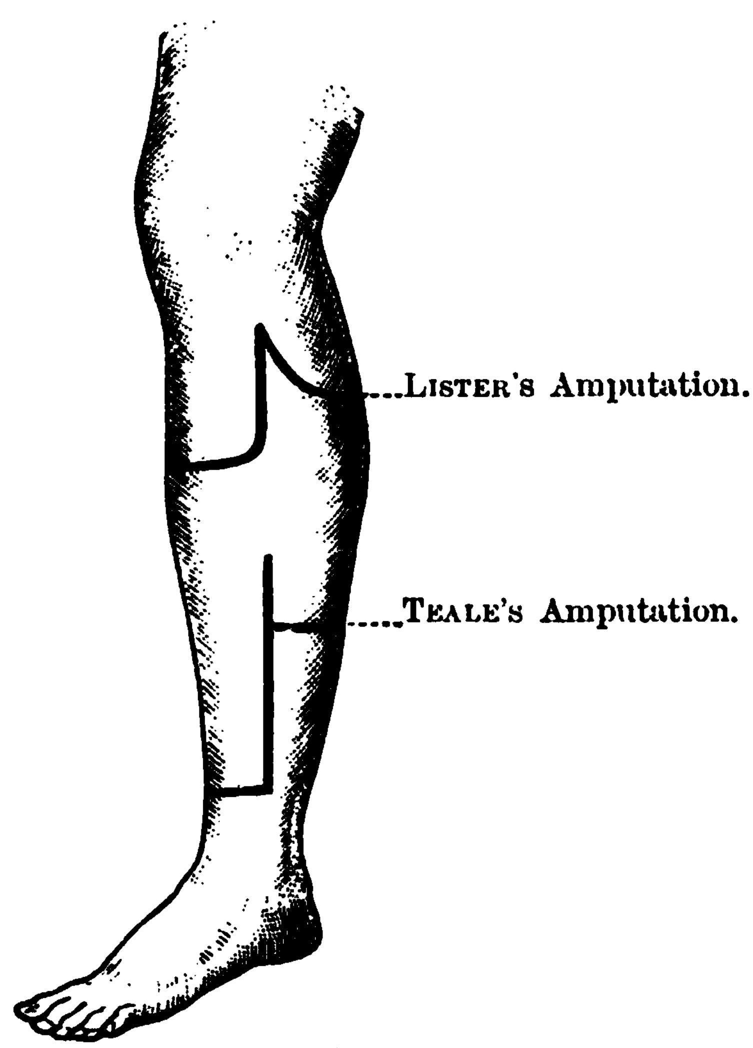
... upper limit of the reflected flaps ... foot well inwards, and the operator ... before the tibia is completely ...

... and dress the stump.

the dorsum of the foot, so as to bring the point of section of the bones as low down as possible, and it must include everything in front of the bones and the interosseous membrane. The anterior tibial artery lies in the middle of this flap, but it is very close to the interosseous membrane, and should the flap be raised in the ordinary way by the knife, the artery is very apt to be punctured during the dissection; to avoid this undesirable accident—as the nutrition of the flap depends on this vessel—we

Fig. 54.

AMPUTATION OF LEG.



must follow Mr TEALE's plan, who has shown that, on account of the comparatively large amount of loose cellular tissue lying between the anterior structures and the membrane, there is no difficulty in separating the flap from its anterior surface by the finger or thumb nail, or the handle of a scalpel. To render this more easy the lateral incisions, marking the limits of the anterior flap, should go through all the soft tissues down to the bone, *especially on the* fibular side, on account of the intimate attach-

ment of the muscles to that bone. To insure that the anterior flap shall be of the same breadth throughout it is advisable, before beginning the operation, to measure with a tape and mark the whole extent of the anterior flap in ink, rather than trust to the eye alone, as the cone-shaped form of the limb is apt to mislead the eye. The posterior flap is then made with the same precautions to avoid injury of the arteries and nerve behind. The tibia and fibula are next to be cleared to the level of the base of the flaps, or a little higher if necessary, by circular sweeps of the knife, first below and then above the bones, the interosseous membrane divided, and the tissues between the bones cleared, by a figure-of-eight-like sweep. To avoid cracking and splintering of the fibula, both bones are to be divided together, but the fibula must be finished before the tibia. Should the angle in front of the tibia be very acute it should be removed, either by the bone pliers or a small saw. The **vessels requiring ligature** are—(1) The anterior tibial at the middle of the apex of the anterior flap; (2) the posterior tibial; and (3) the peroneal artery, both in the posterior flap.

RÉSUMÉ of TEALE's amputation:—

1. Mark out the flaps by the rules already laid down.
2. Make the lateral incisions, and then divide all the soft parts down to the bone at the apex of the anterior flap: the anterior flap should be a perfect square.
3. Reflect anterior flap, using the *handle of the scalpel or thumb nail* to separate it from the interosseous membrane, in order not to harm the anterior tibial artery.
4. Divide and raise the posterior flap.
5. Saw the bones at the upper limit of the reflected flaps: assistant to turn the foot well inwards, and the operator to divide the fibula before the tibia is completely divided.
6. Fix the flaps in position and dress the stump.

2. **Long Anterior Flap**, slightly rounded at the corners, and made by dissection. Mr BELL recommends this method, and it was also used by Mr SYME. It is formed on the same principle and with all the precautions of Mr TEALE's anterior flap, and

must be long enough to fall down over the face of the bones, at the point of section, and the stump of tissue behind them. The posterior tissues are divided by a transverse incision at the base of the anterior flap. This method may be applied to any part of the leg.

3. **Lister's Method** (see page 187).—Take the *diameter* of the limb at the point where the bones are to be divided, and then make a straight longitudinal incision of that length on the inner aspect of the leg, about half-an-inch behind the inner edge of the tibia, and another similar incision on the outer aspect directly over the fibula, but extending one inch higher up than the inner one. The lower ends of these incisions are then united by a nearly transverse incision, with the angles well rounded, where it joins the lateral ones. The knife is next carried behind the bones, and cutting somewhat obliquely, from without inwards, fashions a short posterior flap, about one-half or one-third the length of the anterior, convex downwards, extending from the upper end of the *internal* lateral incision to a point exactly opposite on the other side, and will be therefore about one inch below the upper end of the external incision. The anterior flap is raised as in TEALE'S method, and the bones cleared and sawn at the upper end of the *outer* incision. The fibula and anterior edge of the tibia must be treated in the way already indicated. The flaps are then to be stitched up closely, except at the upper end of the external incision, which is left open for drainage, the limb being placed on its outer aspect. The reason why the lateral incision is carried further up on the outer side, is on account of the difficulty of retracting the soft parts from the fibula, as the bone is sawn an inch higher up than the proper base of the flaps. They can be retracted without any difficulty from the tibia, and therefore the incision is not carried further up than the typical operation demands.

RÉSUMÉ of LISTER through Calf:—

1. Measure with the eye the diameter of the limb.
2. Make a longitudinal incision equal to half this diameter along the inner side of the leg, half-an-inch behind the inner edge of the tibia, from a point one inch below the intended division of the bone.

3. Make a similar incision on the outer aspect, directly over the fibula, but beginning one inch higher up than the one on the inner aspect.
4. Join the lower ends of these incisions across the front of the leg, forming a square-shaped flap with well-rounded angles.
5. In the same way form a posterior flap about one-half or two-thirds the length of the anterior.
6. Reflect both flaps to the level of the upper end of the inner incision.
7. Reflect all the soft parts one inch higher up, clear the bones, and saw them with the usual precautions—fibula thrown well forwards, and divided before the tibia, and the sharp anterior angle of the tibia to be removed.

Other methods are sometimes employed, as—

4. **A Short Anterior Semi-lunar Flap** made by dissection, and a long posterior by transfixion, the bones being divided a little above the base of the flaps.

5 **Modified Circular.**—But of all others the best method is by some form of long anterior flap and short posterior, as in the operations already described; as this affords the best covering, since the bones are placed nearer the anterior aspect of the limb, and the cicatrix is out of the way of pressure, so that the patient can bear a part of the weight of the body on the end of the stump, the rest being supported by the prominence of the calf muscles, and the heads of the tibia and fibula. For the **Structures divided** see "Amputation through the Calf," but adding to the list there given—(1) The peroneus tertius muscle, and (2) anterior peroneal artery.

UPPER TWO THIRDS OF THE LEG.

The limb is to be drained of blood, and hæmorrhage provided against, as in the previous amputations—either by the elastic tourniquet applied above the knee, or else by the thumbs of an assistant pressing on the femoral artery below POUPART's ligament. The **patient** is placed as in the previous operations. In this situation the bones lie nearer the anterior aspect of the limb, and,

therefore, it is not necessary to provide so long an anterior flap in order that the line of the cicatrix be placed well behind.

1. **Long Anterior and Short Posterior Flaps.**—The flaps at first consist of skin and subcutaneous fat only, with muscular tissue taken up towards their bases; in the case of the posterior do not take too much muscle. The limb is held in a way similar to that of the previous amputations, and *rotated well inwards,* so as to throw the fibula well forwards. The **operator** takes his stand on the right side of the limb to be removed, so that he can grasp the limb above the point of amputation, and, in the case of the *right* leg, places his thumb on the fibula, and his forefinger at a corresponding point on the opposite side, which will, therefore, be considerably behind the inner edge of the tibia. On the left side the position of the thumb and finger will be reversed, as the operator then takes his stand inside the limb. He then marks out a broad skin flap, equal in length to two-thirds of the diameter of the limb, the heel of the knife commencing well behind the tibia, its blade sweeping across the front, and its point ending a little behind the thumb; next, without removing the knife from the incision, he transfixes the limb behind the bones, taking care not to pass the knife between them, and making it enter and emerge through the angles of his former incision, so that the blade will pass close behind the fibula, but at some little distance from the tibia. A short posterior flap, about half the length of the anterior, is then cut from within outwards; while the posterior flap is being cut, the assistant holding the foot must keep the muscles tense by dorsiflexing the foot forcibly, while the operator or another assistant pulls up the skin as far as possible. This insures the skin being cut longer than the other tissues, and avoids redundancy of muscle. The operator must next raise the anterior flap, which at first should consist entirely of integumentary structures, but, as its base is approached, as much muscular tissue as possible should be taken up, to insure its nutrition; both flaps are then to be well retracted by the assistant standing opposite the Surgeon, while the knife is swept circularly round the limb at the base of the flaps. The interosseous structures are then to be divided by the usual figure-of-eight-like sweep of the knife, taking *care not* to allow its edge to be directed upwards in the least, lest

the anterior tibial artery especially, or any of the other vessels, be split, and retract beyond the reach of easy ligature. The bones are then to be sawn, and the sharp angle removed from the anterior edge of the tibia. In order to do this, it is usual to commence sawing the bone obliquely from a point half-an-inch above the place where the bones are to be sawn transversely, and when the oblique section has crossed the line of the transverse one, then withdraw the saw and apply it transversely half-an-inch lower down than the commencement of the oblique cut. When the saw is about half-way through the tibia, then alter the direction of the blade, so that it will take up the fibula, which is to be completely divided before the tibia, to avoid cracking and splintering of the weaker bone. The fibula is apt to project at the outer angle, and to prevent this Mr DUNCAN divides it nearly an inch higher up than the tibia. The sharp angle of the crest of the tibia may be removed with the bone forceps, or a small saw, *after* the limb is removed, should the operator so prefer it; this method probably disturbs the periosteum less than the other way. It is well, in order to lessen the risk of necrosis, to split the periosteum along the crest and turn aside two little triangular flaps of that membrane, before the saw or forceps is applied, so that it may not be stripped off to a higher level than that at which the saw is actually applied. The **vessels divided** are—(1) Anterior tibial, (2) posterior tibial, (3) peroneal artery, and (4) the long and short saphena veins, all of which may require ligature. By this amputation the vessels are cut transversely, and the cicatrix is placed behind.

2. **Lister's Amputation.**—Take the diameter of the limb, by spanning, at the point of the intended division of the bone, and then make a straight longitudinal incision equal in length to two-thirds of this diameter, along the inner aspect of the leg, commencing one inch below the point at which the bone is to be divided, and half-an-inch posterior to the inner edge of the tibia. A similar incision is made on the outer aspect, directly over the fibula, but is to be prolonged an inch higher up than the internal incision (*i.e.*, up to the point of section of the bone), for reasons already stated. The two incisions are then united by a transverse cut, with well-rounded angles, at the points where it meets the lateral incisions. A posterior flap is then made from the upper

end of the internal incision to a point exactly opposite that in the external incision—that is, one inch below its upper extremity. This flap should be half the length of the anterior, and is made by carrying the knife round the back of the limb with the blade at an angle of forty-five degrees to the horizon, through the integumentary structures only, and dissecting it up to the level of the upper end of the internal straight incision. By this means we get rid of the heavy mass of muscles of the calf. The anterior flap is dissected up to a similar point, both flaps retracted, and the bones cleared as high as the line of the external incision, and the operation finished as described in the previous amputation (see Fig. 54).

3. **The Modified Circular.**—The leg is held, as in the previous amputations, supported horizontally, and well rotated inwards, so as to throw the fibula well forwards; the **assistant** must also extend the toes forcibly as the operator's knife divides the muscles in front, and dorsiflex forcibly as he divides the posterior group of muscles. In this way the muscles are rendered tense and more easily divided. Another assistant, standing opposite the Surgeon, pulls up the skin well, both before and after the first incisions. The **Surgeon** stands so that his left hand grasps the limb to be removed above the level of the amputation, *i.e.*, on the *right* side; and then cuts two equal semi-lunar flaps of skin from the outside by dissection. In order to cover both bones equally, and avoid their projecting at either of the angles of the incisions, the flaps may be placed rather antero-external and postero-internal. In raising the posterior, the limb should be elevated to enable the Surgeon to see better what he is doing. Both flaps are then retracted and the skin at their bases turned back for a little way, and the muscles divided at that level by a circular sweep of the knife, and the bones cleared for an inch or an inch and a half higher up, and there divided with all the usual precautions. As the posterior muscles, especially the superficial layer, retract further than the anterior (being divided at a greater distance from their origin), they should be divided at a lower level, say, a couple of inches below the base of the skin flap.

Instead of making the skin flaps anterior and posterior, Mr BRYANT uses lateral skin flaps, with circular division of the muscles. *This is* **objectionable**—1. Because the tendon of the quadriceps

extensor cruris tilts the sharp angle of the tibia into the anterior angle of the incision, and is, therefore, likely to interfere with the healing process. 2. Because the scar must necessarily be opposite the end of the bone, and it also extends up both back and front of the stump; hence the patient can neither bear his weight on the end of the stump, nor can he very well manipulate an artificial leg, because of the anterior and posterior scars. In the "modified circular," with anterior and posterior flaps, even though the flaps are equal, the scar is well behind the tibia—(1) because the tibia is so near the anterior surface of the leg, and (2) as the stump heals the posterior muscles contract and drag the scar still further backwards and upwards, so that the patient can bear a great part of his weight on the end of the stump.

Instead of using the pure "modified circular," the anterior skin flap may be made equal to two-thirds of the diameter of the limb, and the posterior half that length. The flaps are then retracted, and the operation finished as above directed. The "modified circular" gives a good stump out of the smallest amount of material, and with the smallest possible wound, and provides an exceedingly useful limb, the patient either being provided with a properly-fitting socket, in which to put the limb, retaining the use of the knee joint, or else resting his whole weight upon the bent knee, as in the old, artificial "box leg."

4. **The Old Flap Operation.**—This is recommended by many Surgeons, especially in cases of chronic disease, where the muscles of the calf are much wasted. It gives a well-covered stump, with the cicatrix in front, on which the patient can bear a considerable part of his weight. In this operation the **Surgeon** stands so that he can grasp the limb below the seat of the amputation—on the inner side, on the right leg, and the outer, on the left. An **assistant** takes his place opposite the operator, and must be prepared to pull up the integument, steady and support the upper part of the limb, and retract the flaps when they are formed. The operator then places his forefinger and thumb on the fibula on the one side, and half-an-inch behind the inner edge of the tibia on the other, and then places the heel of his knife (on the right limb) over the outer margin of the fibula, carries it downwards for about an inch and a half, then sweeps the blade across

the front of the limb in a semi-lunar manner, and then upwards till it reaches a point a little *behind* the inner edge of the tibia, and opposite the commencement of the incision on the outer side. Then, without removing the point of the knife from the incision, he transfixes the limb, the knife entering and leaving a little below the angles of the former incision, and forms a gently rounded flap from the calf, by cutting first downwards for some distance and then gradually outwards; in cutting this flap he should support the mass of calf muscles with his left hand. The anterior flap is then dissected upwards, the assistant holding it while the operator frees it by a few touches of the knife—if preferred, the anterior flap may be dissected up before the posterior flap is made. Both flaps are next retracted, the bones cleared and sawn a little higher up than the point of transfixion, with all the previous precautions. The great **objection** to this amputation is the great mass of muscle left in the posterior flap, which is therefore apt to bag and drop, owing to its great weight, and leads to tension and sloughing; for the same reason it must be kept in position by strapping, etc., and this is a source of great discomfort and pain to the patient, as well as being likely to interfere with primary union of the wound. To get rid of this difficulty to a certain extent, Mr SPENCE advised that the skin of the posterior flap should be retracted and the redundant muscle removed by a single sweep of the knife, thus leaving little more than a skin flap. No doubt this is a great improvement; but even this does not give the **advantages of the large anterior flap,** viz.:—(1) Cicatrix placed behind; (2) a dependent opening for drainage during healing; (3) the long anterior flap is kept in position by its own weight; and (4) the tendency to protrusion of the bone is less and ulceration of the flap is rare, as the heavy muscular mass in the posterior flap is avoided.

5. **Lee's Amputation through the Calf.**—This amputation resembles, in a general way, TEALE'S amputation, only the long rectangular flap is made from the tissues behind instead of from the front. The incisions are made at first through the skin and cellular tissue only, and when this has retracted, by virtue of its own elasticity, the muscles are divided; the superficial muscles only are included in the posterior flap, the deep muscles with the large vessels and nerves are cut at the base of the flaps. It was

hoped by this method to combine all the advantages of TEALE's amputation together with the ease of performance of the old flap method. But, as already pointed out, the question of ease and time is not of so much importance now-a-days, as it is to secure a good, useful stump.

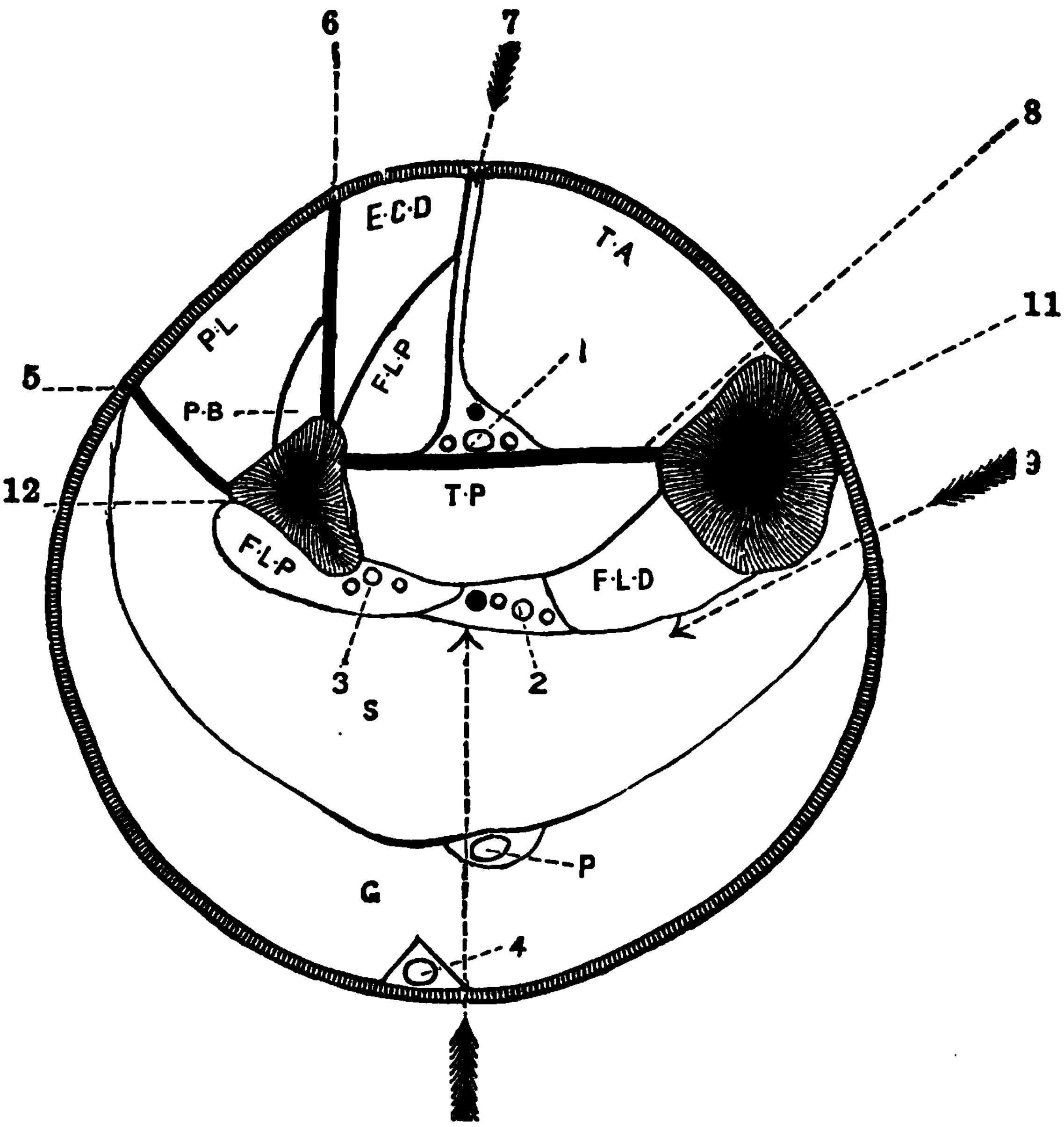
6. **The Circular Method** (*"triple incision"*) may be used in cases where there is not sufficient skin to form a long anterior flap. The steps of the operation resemble very closely those of the modified circular, the only difference being that the skin is divided circularly instead of in the form of two short equal semi-lunar flaps; the skin should be divided three or four inches below the point at which the bone is to be divided.

The foregoing six methods may all be employed either in the middle third of the leg, or at the old "seat of election." The "seat of election" is about a hand's-breadth below the knee joint, and leaves just sufficient tibia to retain its tubercle, with the insertion of the ligamentum patellæ. In practice, however, it will be found more convenient to go a little lower down if possible. If the bones are divided at the "seat of election," some difficulty will probably be experienced in securing the anterior tibial artery, which at that point is just passing through between the bones, and is therefore apt to retract after division, beyond the reach of easy ligature (see page 181); but, by going a little further down, the artery is fairly through and lying on the anterior surface of the interosseous membrane and may be more readily secured. The head of the fibula should always be left, because, as a rule, its synovial membrane is but a part of the general synovial membrane of the knee joint. In regard to arteries divided in amputations a little below the knee, Mr HOLDEN has pointed out that in amputations *one* inch below the head of the fibula *one* artery is divided—the popliteal; at *two* inches below the head, *two* arteries—the anterior and posterior tibials; at *three* inches below the head, *three* arteries—the anterior and posterior tibials and peroneal.

The **Chief Structures divided** in the foregoing amputations through the calf (Fig. 55) are—1. The integumentary coverings. 2. **Muscles**—(*a*) Tibialis anticus, (*b*) extensor communis digitorum, (*c*) the extensor proprius hallucis, (*d*) the peroneus longus, (*e*) the peroneus brevis, (*f*) the gastrocnemius, (*g*) the soleus, (*h*) the

Fig. 55.

SECTION THROUGH THE CALF.



1. Anterior tibial vessels and nerves.
2. Posterior tibial vessels and nerves.
3. Peroneal vessels.
4. Short saphenous vein.
5. Septum between peronei and posterior muscles.
6. Strong septum between peronei and anterior group of muscles.
7. Weak septum in anterior group, through which the anterior tibial artery is reached.
8. Interosseous membrane.
9. To show position of lateral incision.
10. To show position of direct incision (GUTHRIE's).
11. Tibia.
12. Fibula.

The names of the Muscles are indicated by their initial letters.

NOTE.—In the Anterior group of Muscles, instead of F.L.P., read E.P.P.—Extensor Proprius Pollicis *vel* Hallucis.

plantaris, (*i*) the flexor longus digitorum, (*j*) the flexor longus hallucis, and (*k*) the tibialis posticus. 3. **Vessels**—(*a*) The long saphenous vein, (*b*) the short saphenous vein, (*c*) the anterior tibial vessels, lying on the interosseous membrane; (*d*) the posterior tibial vessels, lying on the tibialis posticus; and (*e*) the peroneal vessels (about the middle of the leg these will be found in the substance of the flexor longus hallucis, higher up they will be found lying on the tibialis posticus). 4. **Nerves**—(*a*) The short saphenous or the branches going to form it, (*b*) the anterior tibial nerve, (*c*) the posterior tibial nerve, and (*d*) the peroneal or musculo-cutaneous nerve. 5. The tibia and fibula. 6. The interosseous membrane.

THE KNEE JOINT.

Amputation at the Knee Joint Proper (leaving the Condyles). —This is an amputation but rarely performed, although of recent years it seems to be reviving, being specially advocated by Mr BRYANT. The difficulty is to get sufficient covering, on account of the large size of the lower end of the femur. In the case (1) of *disease* of the joint there can be no doubt that the amputations of CARDEN or GRITTI are immensely superior to amputation at the knee joint, for the proper performance of which it is necessary that the articular surfaces of the condyles and patella should be healthy Many Surgeons, however, operate thus—even in disease of the joint—and after disarticulation is completed, use a fine-bladed BUTCHER'S saw and cut *round* the end of the bone, thus removing the diseased surface without shortening the stump or lessening its breadth. An objection to this proceeding is that the cancelli may be opened up and predispose to osteo-phlebitis and pyæmia. For this reason, when the cartilages are healthy they should be left undisturbed on both femur and patella; and the cartilage, if removed from the one, should also be removed from the other. In the case (2) of *injury*, when the integuments are uninjured for *five* inches below the patella (the length of the anterior flap in amputation by the long anterior skin flap—the best method), it is better to amputate by the "modified circular" at the old seat of election. It may, however, be practised in the case of malignant disease of the head of the tibia, provided the femur and knee joint are healthy, and in gun-shot wound of the same bone.

1. **By Long Anterior and Short Posterior Flap.**—This is the method usually preferred. The **patient** is brought well down on the table, so that the knee projects beyond it, while his other leg is secured to a leg of the operating table. One **assistant** holds the leg in an extended position while the anterior flap is fashioned, another supports the thigh and pulls back the skin. The **guides** for the anterior flap are the lower and back part of each condyle, and a point an inch or more below the tubercle of the tibia. The flap should be broad and somewhat square-shaped, with its lower angles well rounded, and must be at least five inches long. It will be convenient for the **Surgeon** to stand on the right side of the limb to be amputated, so that he may himself raise up the large anterior flap with his left hand; he should be provided with a short, broad-bladed, amputating knife. The anterior flap is then marked out in the manner indicated, the ligamentum patellæ divided, and the integument, with the patella and capsule, are dissected up in front of the joint; in this way the articulation is opened. One assistant now flexes the knee joint, and another supports the thigh, while the operator divides the lateral and crucial ligaments, and passes the knife straight backwards between the bones, turns it down behind the tibia, and cuts a posterior flap fully one-half the length of the anterior. This flap may be made by cutting from behind forwards, instead of from before backwards. In both cases the knife must be made to enter or leave the tissues abruptly, so as to keep the end of the flap squarish and divide the popliteal artery transversely. The flap must not be made any *shorter* than the length given, as it shows a considerable tendency to retract. The treatment of the patella is a disputed point. On the whole, I think, Surgeons are inclined to leave it, as it fills up the hollow between the condyles, to which it may or may not become ankylosed; in any case, it protects the end of the stump, and the position of its bursa makes it useful in supporting the patient's weight. The only objection to this is that it is occasionally drawn up in front of the thigh by the quadriceps extensor cruris; this may be prevented either by cutting the tendinous insertion of that muscle into the patella, or by "wiring" the patella to the condyles by silver wire or strong catgut. If the patella is to be removed, it may either be done during the formation of the anterior flap, by

dissecting it off and cutting above it when opening the joint, or it may be dissected out after the flap is raised; but by removing it the bursa is lost, and the flap is so thinned that it is apt to perish by sloughing. A most important part of the after treatment is the proper **drainage** of the wound, as in all cases where large synovial pouches are opened. This is best accomplished by the introduction of two long drainage tubes, inserted into the extreme upper corners of the pouches and their ends brought out at the two angles of the wound. They must not be interfered with till the third day, and must never on any account be completely removed during the dressing of the wound, as it would probably be impossible to replace them; they must simply be withdrawn half-an-inch or so at each dressing, and the projecting piece cut off, as the wound heals. An **objection** to this method is the very long anterior skin flap, which may possibly slough, as compared with amputation at "the seat of election" by the "modified circular," where the skin flaps have no tendency to slough. An **advantage** of amputation *at the knee* is that there is no sawn bone surface, which is a great advantage if by any chance the wound were to become septic.

2. **Short Anterior and Long Posterior Flap.**—The leg is held as in the previous operation, and the **Surgeon** may either stand on the right or left side of the limb. A slightly curved incision is made from the lower and back part of one condyle, passing just below the patella, and ending at the lower and back part of the other condyle. This flap is then dissected up, the knee flexed, and the joint opened above the patella, by a semi-circular sweep of the knife. The lateral and crucial ligaments are next divided, the bones fully separated by dividing the posterior ligament, and the knife passed behind the tibia with its edge directed downwards, and a large flap about four or five inches long cut from the upper part of the calf of the leg. In making this posterior flap the assistant must flex and displace the tibia a little forwards till the knife is fairly behind it; then the skin is to be drawn well upwards and the leg extended as the knife cuts the flap. As usual, the knife must be carried down close to the bone for some distance, and then brought abruptly out so as to make the end of the flap rather square than round. The great objection to this amputation is the tendency of the posterior flap to retract.

3. **By Lateral Skin Flaps** (STEPHEN SMITH, New York).—Two convex lateral incisions are made from a point on the anterior edge of the tibia, one inch below the tubercle, and carried downwards and backwards, round the two sides respectively, over the most prominent part of the side of the leg, and are then directed upwards, reaching the median line posteriorly at a point opposite their commencement. From this a single straight incision is carried directly upwards to the centre of the popliteal space. The flaps are then raised, the ligamentum patellæ divided, disarticulation performed, and the limb removed. The patella is left, and the internal flap is rather larger than the external. It will be observed that this somewhat resembles the "oval" method of amputation, with the muscles divided obliquely towards the bones. The flaps here form two lateral hoods, one over each condyle; the covering thus provided is good, and the drainage is free behind. According to Mr BRYANT, the **advantages** of this amputation over amputation through the thigh are—(1) Less shock; (2) less section of tissues, and the muscular interspaces of thigh are not opened up; (3) femur is not cut, and, therefore, the risk is much less; (4) the stump is mobile, because the attachments of the muscles of the thigh are preserved; and (5) a very useful stump is left. This method may also be used for the leg and lower part of the thigh. I have only seen amputation *at* the knee performed once, and that was by Professor CHIENE, in a case where the leg was useless, being too small and partially luxated backwards from previous disease. Two straight lateral incisions were made from a point a little below the condyles of the femur, and then two rectangular flaps formed, the anterior being about twice the length of the posterior; the flaps were then carefully dissected up—the anterior especially requiring great care—to the level of the articulation, the joint opened, and the leg removed. The result was excellent, a most useful and beautiful stump resulting.

In amputation at the knee joint the **Structures divided** are—1. The integumentary coverings. 2. **Muscles**—(*a*) The lower part of the quadriceps extensor cruris, (*b*) the adductor magnus, (*c*) the gracilis, (*d*) the hamstrings, (*e*) the sartorius, (*f*) the gastrocnemius (*g*) the plantaris, (*h*) the soleus, and (*i*) the popliteus. 3. **Vessels**—(*a*) The popliteal artery (in the posterior flap) with its lower

articular branches, (*b*) branches of the anastomotica magna of the femoral, (*c*) long and short saphena veins, and (*d*) the popliteal vein. 4. **Nerves** — (*a*) The internal popliteal with its *ramus communicans tibialis*, (*b*) the external popliteal with its *ramus communicans fibularis*, (*c*) cutaneous nerves of this neighbourhood, and (*d*) branches of the obturator nerve supplying the knee joint. 5. The ligaments of the knee joint.

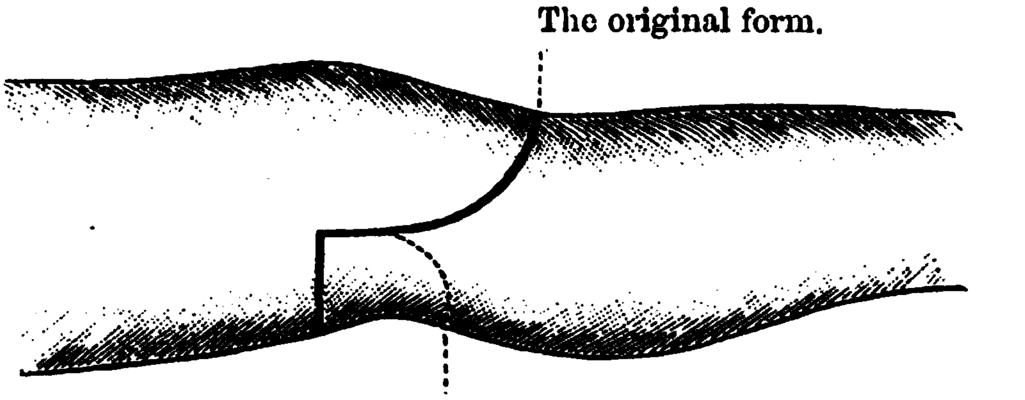
AMPUTATION THROUGH THE CONDYLES.

This is often spoken of as amputation *at* the knee joint, and is more frequently performed than that operation.

1. **Carden's Amputation** *(slightly modified)*.—This is analogous to SYME's amputation at the ankle joint, and was introduced by Mr CARDEN in the year 1864. The **guides** are the two condyloid eminences of the femur, towards their posterior part, and which correspond to the broadest part of the articular end, and the tubercle of the tibia. CARDEN himself simply made an anterior

Fig. 56.

CARDEN'S AMPUTATION.



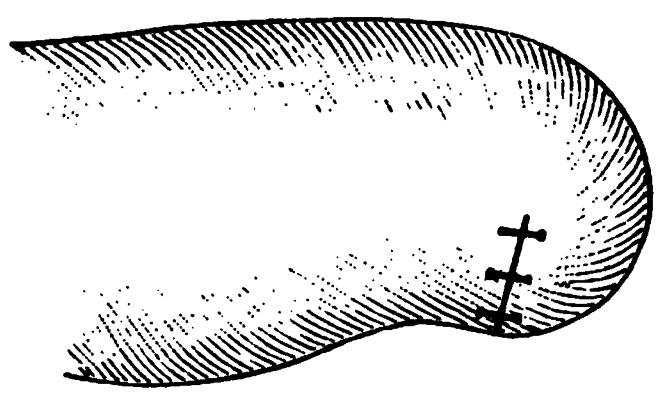
flap, removing the patella, and cut through everything on the posterior aspect straight out at the base of the anterior flap, not making a posterior flap at all (Fig. 56). Other operators, however, have found that without a posterior flap the covering is frequently insufficient, especially in cases where the leg has been fixed in the flexed position by disease. The **patient** is placed as in amputations through the knee joint, and an **assistant** holds the limb with the knee joint slightly flexed, as in this way we get a longer anterior flap than when it is flexed to a right angle at once. The **Surgeon** stands on the right side of the limb, and places his finger and

thumb on the two condyloid eminences of the femur, and, therefore, nearer the posterior part of their lateral aspect than the anterior. He then marks out a long anterior flap, reaching as low as the tubercle of the tibia—the knife being entered behind, and close to his finger, and brought round to a point, close to and behind his thumb, or *vice versâ*, according to the limb. The flap should be broad, and its edges at first straight, and its lower angles well rounded. It is then dissected up, with or without the patella; if without, when the dissection has proceeded as far as the centre of that bone the assistant forcibly flexes the knee to a right angle; this pulls the patella down, and then the operator cuts into the joint by a semi-circular sweep of the knife above the upper edge of the patella and immediately above the condyles.

Fig. 57.

THE STUMP AFTER CARDEN'S AMPUTATION.

(Original Form.)



When the soft parts are much thickened and matted by disease the patella may be turned up with the flap and dissected out afterwards. The lateral, crucial, and posterior ligaments are next divided, the knife passed behind the femur, and a posterior flap cut from within outwards nearly equal in length to the anterior; it is better to make it pretty long, because it contains the hamstring tendons, and will retract considerably. Mr BELL makes a skin flap about an inch and a half long, allows it to retract, and then divides the muscles by a circular cut down to the bone at the level of the retracted skin. Both flaps are then retracted, the bone cleared to the highest point of the articular surface, and then sawn through at the broadest part of the condyles, or *just below* the "adductor tubercle;" the saw must be applied parallel with the articular surface of the femur, and not at right angles to the long

axis of the bone, and to avoid injurious pressure on the anterior flap, the sharp anterior edge of the condyles may be *rounded* off by a narrow-bladed and fine-toothed BUTCHER'S saw. It is not necessary to adhere strictly to the order of the operation as above described; the anterior flap may be cut and raised, the knee joint examined if the Surgeon is undecided between excision and amputation, the bone sawn as in excision, and then, should amputation be deemed necessary, the posterior flap of skin is marked out, allowed to retract, and then the muscles and vessels divided last of all. By this plan the patella is raised with the anterior flap, and will require to be dissected out before completing the operation. In performing this amputation, Mr HEATH at once flexes the knee to a right angle, makes the first incision and reflects the anterior flap, then transfixes the limb behind the condyles, and forms the posterior flap.

As compared with amputation through the lower third of the thigh, CARDEN'S amputation has the following **advantages**:— 1. It is less serious because further from the trunk, and there is therefore less shock, etc. 2. The parts divided are not vascular, and there is, therefore, less risk of hæmorrhage. 3. The tendency to protrusion of the bone is less, because of the ample coverings, and less tendency to necrosis, osteo-myelitis, osteo-phlebitis, and pyæmia, as the medullary canal is not opened. 4. A longer stump, and therefore greater command over the artificial limb. 5. The end of the stump is well adapted for bearing pressure, being of great breadth; and, further, because the skin forming it is accustomed to bear pressure, and the cicatrix is situated behind. 6. In cases of doubt as to whether amputation or excision is the proper mode of procedure, the anterior flap can be raised, the joint examined, and the further proceedings decided; for, just as at the shoulder, it is very easily transformed into an amputation.

RÉSUMÉ of CARDEN'S amputation:—

1. Assistant to hold the limb slightly flexed—probably already so by disease.
2. Operator stands on the right side and defines bony guides—tuberosities of the femur, at their upper and posterior part, and the tubercle of the tibia.

3. With these points in view, shape the anterior flap; it should be square-shaped with the angles rounded off, the base being on a level with the femoral tuberosities, and the apex almost on a level with the tubercle of the tibia.
4. Reflect this flap to the centre of the patella, then flex the knee forcibly, and let the knife sink into the tissues above the patella, down to the femur.
5. Reflect the soft parts to the level of the adductor tubercle, and divide the lateral and crucial ligaments.
6. Pass the knife behind the femur, again extend the limb, and cut a posterior flap from within outwards about half the length of the anterior.
7. Clear the femur, and divide it through the condyles, just below the adductor tubercle.

2. **Gritti's Amputation** *(slightly modified).*—This to a certain extent resembles very closely CARDEN'S amputation. We have the same **guides** for the anterior flap, which is dissected up *with the patella.* The operation is finished as in CARDEN, the articular surface of the patella is sawn off, and the denuded surface hangs over the end of the femur. The femur is divided about one-third of an inch higher up than in CARDEN, to insure that the patella will hang flatly over it and not tilt. The point of division is *just above* the "adductor tubercle." It has been advised, just as in amputation at the knee joint proper, to divide the tendon of the quadriceps extensor cruris, or "wire" the bones to keep it from tilting. This amputation, therefore, has the same relation to CARDEN'S as PIROGOFF'S has to SYME'S amputation at the ankle joint. Its great **advantage** is that the bursa patellæ is retained, upon which the patient can bear a great part of his weight; there is probably also less risk of sloughing of the anterior flap. An alleged **disadvantage** is that, the femur being divided higher up, the medullary canal is more apt to be opened, and the patient therefore runs more risk of osteo-myelitis and its consequences, as section through the medullary canal is more risky than section through the spongy tissue, and this again is more risky than where the end of the bone is covered with cartilage, as amputation at the knee joint. Further, for the same reason, the end of the stump is

not quite so broad as in CARDEN. In denuding the patella of its cartilage, an assistant must at first grasp it transversely with a lion forceps, and hold it vertically down upon the femur till the saw has made a groove for itself. After that he changes the direction of the forceps and grasps the patella vertically, but only taking a very narrow bite so that the teeth of the saw may not come into contact with the lower blade; or the operator himself may hold the flap and patella with his left hand and saw vertically downwards. Another plan is to lay the flap and patella into the palm of the left hand and there denude it, the hand being first covered with a towel.

Stokes's Supra-Condyloid Amputation of the thigh differs from GRITTI's amputation in that the femur is divided about an inch higher up. STOKES divides the femur at least half-an-inch *above* the upper edge of the trochlear surface, whereas GRITTI saws through the condyles just above the "adductor tubercle," but in both cases the patella is denuded of its cartilage and applied to the cut surface of the femur.

Lister's Modification of Carden *(a form of "modified circular")*. —He suggested this method to lessen the risk of sloughing of the large anterior skin flap in CARDEN. The integuments behind are also made to take a larger share in forming the covering, and therefore it is not necessary to go so far down the limb in front, and hence it might be used in cases of injury. The **incisions** he advises are the following:—The limb being extended, the **Surgeon** stands on the right side and cuts almost transversely across the front of the tibia from side to side, at the level of the tubercle of the tibia, and joins the horns of this incision by carrying the knife at an angle of forty-five degrees to axis of the leg through skin and fat. The leg is then elevated and the posterior flap dissected up, and the ring of integument reflected as in the circular operation, dividing the hamstrings as they are exposed. The knee is next flexed, and the upper border of the patella exposed, when he cuts into the joint above it by a semi-circular sweep of the knife. The bones are now cleared and sawn as in CARDEN's amputation.

For the **Structures divided** in the three foregoing amputations, see "Amputation through the Knee Joint Proper." Of course, the section through the femur must be added in all, and in GRITTI, section of the patella as well.

CHAPTER XVII.

AMPUTATIONS OF THE LOWER EXTREMITY

(Continued).

The Thigh.—In all amputations through the thigh the amount of flap length allowed should never be less than twice the diameter of the limb at the point where the bone is sawn, and, if possible, the anterior flap should be longer than the posterior.

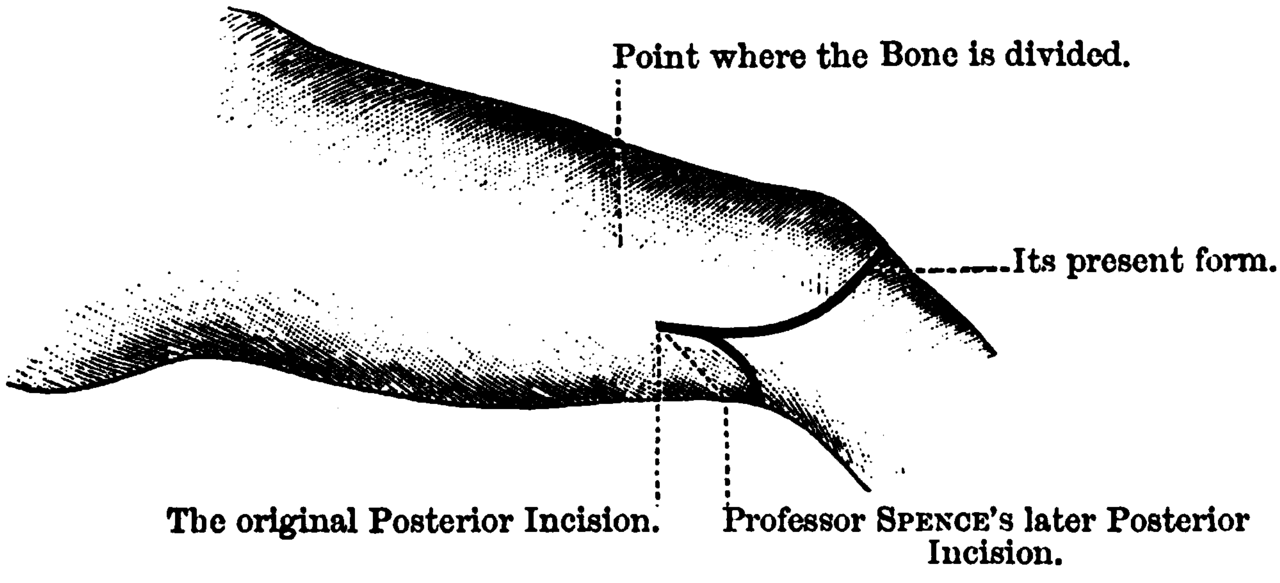
THE LOWER THIRD.

1. **Spence's Method** (1856), by long anterior flap (see page 186).—An **assistant**, seated in front of the patient on a low stool, holds the limb firmly below the knee, so that the thigh shall be horizontal and projecting from the buttock over the edge of the table; another assistant takes his place opposite the Surgeon. The **Surgeon** stands on the right side of the limb to be amputated. Mr SPENCE, however, directs him to stand on the left side, so as to command the bone whilst he is sawing. He then measures, with his eye, the breadth of one-half the circumference of the thigh, and inserts his knife into the side of the limb furthest from himself, well towards the posterior part, and about three inches nearer the trunk than the patella, carries the incision downwards to a point on a level with or below the lower edge of the patella, sweeps across the front of the knee with a gentle curve, and then straight upwards, and ends at a point exactly opposite to that at which he commenced, the assistant standing opposite him, retracting the skin and fascia all the while. The leg is still kept in the extended position, and the Surgeon dissects up the flap from off the patella, taking care not to button-hole it, and, on reaching the upper border of that bone, he cuts deeply and obliquely upwards, so as to take up the

muscular tissue as well, towards the base of the flap; the flap should be nearly as broad at its apex as at its base, and is at first composed of skin and fascia only. He next shapes a posterior flap, beginning three inches below the base of the anterior flap, making a convex incision through the integuments, and cuts the other soft tissues obliquely upwards towards the bone; or better, first dissect back the skin for about an inch before dividing the muscles. The leg assistant now elevates the limb to a right angle with the table, retracts the soft parts gently, and the bone is cleared by a couple of sweeps with the knife, *two inches* higher up than the base of the flaps, immediately above the condyles. By elevating the thigh, the bone is projected

Fig. 58.

SPENCE'S AMPUTATION.



to the utmost, and, when the limb is brought down again after sawing, it will be found to be deeply buried among the soft parts; as soon as the bone is divided *all further retraction must be avoided*, lest the periosteum be stripped off the bone that remains, and lead to necrosis. The younger the patient the more necessary is this precaution, as the deep layer of the periosteum is more cellular and therefore less adherent in the young than it is in the old. The femoral artery will be found towards the inner side of the *posterior* flap when the operation is properly performed, and should not, on any account, form part of the anterior flap; the other vessels requiring ligature are the terminal

branches of the profunda among the adductors, the descending branches of the external circumflex, the comes nervi ischiadici beside the great sciatic nerve, and probably branches of the anastomotica magna.

RÉSUMÉ of SPENCE's amputation:—

1. Measure with the eye the half circumference of the limb.
2. Recognise the guides to the operation—a point just above the femoral tuberosities ("condyles") for the bases of the flaps, and lower margin of patella for its apex.
3. Sweep the knife through these points, forming a broad, square-shaped flap, with well-rounded angles.
4. Dissect up this flap from off the patella and front of the knee joint; at the upper edge of the patella cut deeply and obliquely towards the femur.
5. Apply the edge of the knife to the skin on the posterior aspect, about *three inches* below the base of the anterior flap, forming a convex flap, and then divide the tissues obliquely to the bone.
6. Retract the soft parts, clear and saw the femur a little way above the condyles.

Teale's Amputation (1856).—This is performed according to the rules given elsewhere. Measure the circumference of the limb at the point where the bone is to be divided, and then mark out the long flap, making its length and breadth each equal to one-half of the circumference of the limb. Trace out the inner longitudinal line first, making it as near as possible to the femoral vessels, without including them in the anterior flap. If the tissues are healthy, the anterior flap may be taken from the front of the knee joint and patella. The posterior flap is next marked out, and its length is to be one-fourth that of the anterior. The lateral incisions are first made, and must only go through the integumentary structures. The anterior flap will probably at first only consist of skin and fascia, but above the upper border of the patella it must include everything down to the thigh bone. The posterior flap is made by a single sweep of the knife down to the bone through muscles, vessels, and nerves. The bone is then cleared and sawn close to the base of the flaps.

3. **The Circular or Modified Circular** may also be used. In the modified circular two equal anterior and posterior semi-lunar flaps of skin are cut according to the method explained elsewhere; they are then retracted to a distance equal to half the diameter of the limb, and the muscles divided obliquely down to the bone by a circular sweep of the knife. On account of the unequal retraction, the posterior muscles must be cut much lower than the anterior. All the tissues are then retracted, the bone cleared and sawn.

4. **By Lateral Flaps** (VERMALE).—He introduced this method because the muscles in this part of the limb are chiefly lateral, the central parts in front and behind being tendinous, and, therefore, if anterior and posterior flaps were used they would be thin and tendinous in the middle. Lateral flaps are not so, but have the **disadvantages**—(1) Of leaving the cicatrix over the end of the bone; (2) they are difficult to keep in position; (3) the bone tends to be tilted forwards by the psoas and iliacus, and projects at the anterior angle of the flaps; just as the deltoid tilts the humerus in amputation through the middle of that bone by anterior and posterior flaps. It has one advantage, however, namely, that it provides a free exit for discharges during the process of healing. The limb is held as described under SPENCE's amputation, and the Surgeon in all cases stands on the outer side of the limb, and the outer flap is always to be made first, as it contains no vessels of consequence. The Surgeon grasps the soft parts on the outer side with his left hand, and draws them outwards, enters the point of the knife perpendicularly in the middle of the thigh, about three inches above the upper border of the patella, thrusts it downwards, passing closely round the bone, and brings it out in the centre of the ham; the flap is then cut downwards and outwards. The knife is again entered at the upper angle of the incision, carried closely round the inner side of the bone, taking care not to transfix the femoral artery, and brought out through the lower angle of the first incision, and a flap cut equal in length to the external one. The limb is then elevated, the flaps retracted, the bone cleared, and the saw applied about four inches above the condyles. In certain cases where the tissues are damaged on one side only, it may be found advantageous to use the lateral flap method; in other cases, however, it ought to be avoided.

5. **Lister's Method.**—See under "Amputation of Middle and Upper Thirds of Thigh" for description.

6. **Skin Flaps.**—This is hardly a separate method, but should be adopted in cases of malignant disease. The flaps should, if possible, be anterior and posterior, and are to be made by dissection, and the other tissues divided circularly above the diseased part. The posterior flap should be raised first, otherwise the bleeding from the anterior will embarrass the operator.

The method of amputation by **double transfixion** is not usually adopted in the lower third of the thigh. The *muscular* flaps—the necessary result of this method—tend to retract too much and lead to protrusion of the bone; the posterior one especially retracts, as the hamstrings are cut so far from their origin, and leave a gaping wound to heal by granulation. This is specially manifested when the limb is flexed—the position of greatest comfort to the patient.

For the **Structures divided** see next set of amputations.

THE MIDDLE AND UPPER THIRDS.

For the different methods of restraining **hæmorrhage** in amputations through the *upper* part of the thigh, see "Amputations at the Hip Joint." In amputating in these situations we must save as much as possible, for it is of more importance to preserve the life of our patient than to secure an artistic stump, and statistics show that every inch nearer the trunk increases the mortality. In all probability therefore the best method is the—

1. **Modified Circular.**—By this method we can secure the longest possible stump out of the structures at our disposal. The **operator** stands on the right side of the limb, and three **assistants** are required—**one** seated in front of the patient, to support the limb below the seat of amputation, a **second** to support the thigh and retract the integument, and a **third** to command the femoral artery. The **patient** is brought well down towards the end of the table, and his other leg is secured to a leg of the operating table by a clove hitch. The two short skin flaps may be taken from the most convenient position; if it is a matter of choice, then make them anterior and posterior. Retract the flaps of skin and divide the muscles,

taking care that the posterior ones are divided at a lower level than the anterior. Next retract all the tissues and saw the bone higher up. Lateral flaps are not good in the thigh as the bone tends to project at the upper angle between the flaps. In wasted and almost cylindrical limbs the ordinary circular, or "**triple incision,**" may be adopted.

In the **Circular Method** the **operator** stands on the outer side of the limb. One **assistant** supports the limb horizontally, while **another** encircles the limb with both hands above the seat of the amputation, and retracts the integuments; and, in the living body, a **third** must compress the femoral artery against the brim of the pelvis. In all cases of thigh amputations, the **patient** is laid upon his back, with his buttocks close to the edge of the table, the leg to be amputated projecting horizontally from it, and the other secured to a leg of the table.

2. **Double Flaps by Transfixion.**—The anterior flap must be equal in length to two-thirds of the diameter of the limb at the point of section of the bone; the posterior, half that length. The position of the **patient** and the **assistants** required are the same as in the previous operation, and the **Surgeon** stands, most conveniently, on the right side of the limb. The assistant, standing opposite the operator, places the palm of his hand on the posterior part of the thigh to be amputated, so as to press up the soft parts and relax those in front. The operator then grasps and raises the anterior structures with his left hand and transfixes the limb an inch and a half below the point where the bone is to be sawn, passes the knife close in front of the bone and femoral artery (below the middle of the thigh), so as to give a broad flap, as nearly as possible equal to half the diameter of the limb. The knife is again re-entered *one inch below* the point of the first transfixion, lest the heel cross-cut the tissues at the angle, and the posterior flap cut from the back of the thigh. The assistant then raises the thigh and retracts the flaps, while the operator prepares the bone for the saw, about an inch and a half above the base of the flaps. In sawing the femur the *linea aspera* must be regarded as a separate and small bone, and the femur must, therefore, be divided in the same manner as the tibia and fibula, the saw first entered well on the dorsal aspect of the bone,

and then brought nearly vertical, so as to divide the *linea aspera* early. The assistant must at the same time support the leg evenly, so as neither to lock the saw nor snap and splinter the bone and to secure this the assistant should be directed to *make gentle traction* in the long axis of the bone being divided. After the bone is divided the assistant holding the thigh must avoid retracting the flaps any more lest the periosteum be stripped off the bone.

The **Anterior Flap** may be **raised by dissection,** the first inch or so consisting only of the integuments, and its base an inch lower than the point where the bone is to be sawn. This flap is then retracted by the assistant and the Surgeon passes the knife beneath the bone, places his left hand under the muscular mass and cuts the posterior flap; the knife is carried down parallel to the bone for some distance and then brought sharply out. The bone is then cleared for an inch higher up, and sawn.

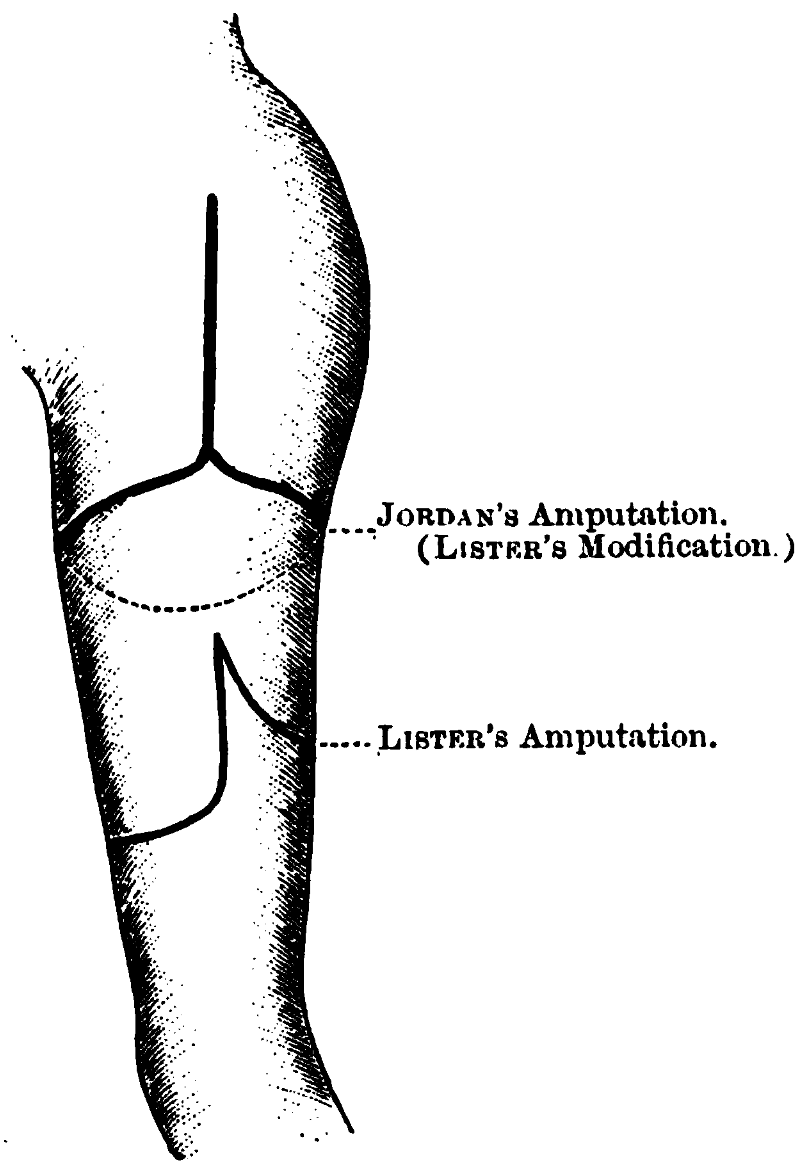
As regards the **vessels divided**—(1) The femoral vessels at any point below the middle of the thigh will be found at the inner side of the posterior flap; above the middle of the thigh they will be at the inner side of the bone, and at the upper part they will be in front of the bone. (2) The termination of the deep femoral, towards the outer aspect of the posterior flap, close to the bone. Besides these (3) the perforating and (4) muscular branches may also require ligature. The position of the femoral artery matters but little, provided the operator takes care not to transfix it, which he is very liable to do about the middle of the thigh, but this can be avoided by not going too close to the femur on the inner side, and leaving the vessels to be divided by the circular incision (HEATH).

3. **Lister's Method.**—The limb is held as in previous amputations of the thigh, and the **Surgeon** stands on the right side of the limb to be amputated, as by so doing he can better raise the flaps with his left hand. He then makes two straight incisions through the skin and fat, along the lateral aspects of the limb parallel with its anterior surface, and each equal in length to two-thirds of the diameter of the limb. At the lower ends they are united by a transverse incision curved upwards at its extremities, where it joins the longitudinal ones. In this way a square-shaped flap is formed with well-rounded angles.

The knife is then passed round the back of the thigh at an angle of forty-five degrees to the axis of the limb, marking out a short posterior *skin* flap; the assistant then elevates the limb, and the posterior flap is dissected up at once (Fig. 59). By making the posterior flap of skin only there is but little danger of its retracting too much, as it is freed from the hamstring muscles. The anterior flap is next raised, and at first consists only of skin and fascia, but, as the bone is approached, a moderate amount of muscle is

Fig. 59.

AMPUTATION OF HIP AND THIGH.



included. The assistant now retracts the soft parts, the knife is swept circularly through the muscles so as to expose the bone about two inches above the angle of the flaps, where the saw is applied and the bone divided *secundum artem.*

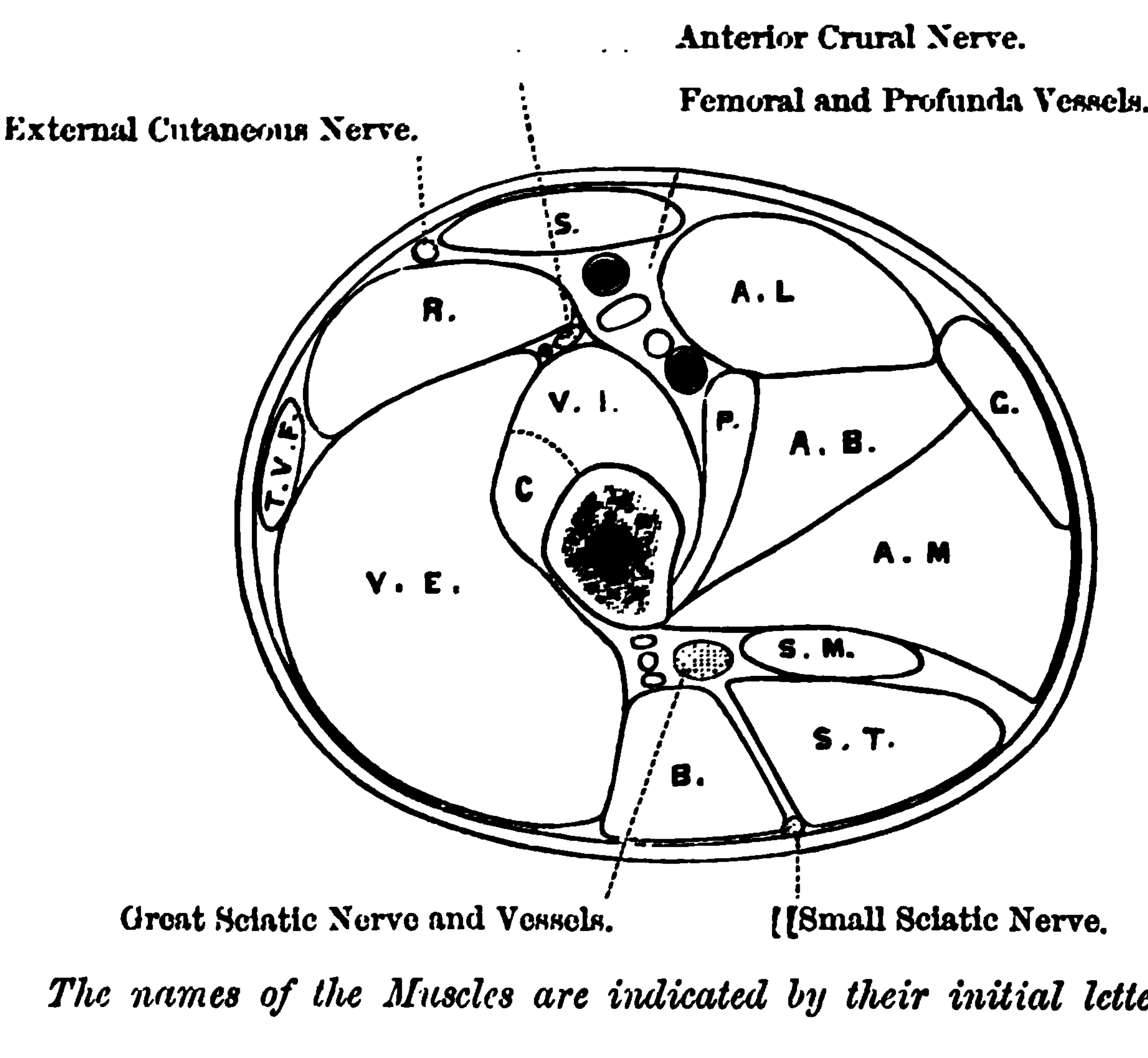
It has been suggested by M'GILL that two short periosteal flaps should be cut to cover in the end of the bone: the flaps are cut, held aside, and the bone divided, and then the flaps brought over the sawn surface.

RÉSUMÉ of LISTER'S amputation through the middle of the thigh :—

1. Make internal and external lateral incisions, each equal to two-thirds of the diameter of the limb, from a point about two inches below the point where the bone is to be divided.
2. Join the lower ends across the front of the thigh, forming a square-shaped flap with well-rounded angles.
3. Shape the posterior flap, making it fully half the length of the anterior, cutting at an angle of forty-five degrees to the axis of the limb.
4. Raise both flaps to the upper limit of lateral incisions.
5. Then retract all the tissues for fully an inch, clear the femur, and saw it. After the periosteum has been divided, do not pull back the flaps any more; and in sawing the bone direct the assistant to make gentle traction in the axis of the limb, to avoid splintering.

Fig. 60.

SECTION THROUGH THE THIGH.



The names of the Muscles are indicated by their initial letters.

In amputations through the thigh, the following **Structures are divided**, speaking generally (Fig. 60):—1. The integumentary coverings. 2. **Muscles**—(*a*) The quadriceps extensor cruris, (*b*) the sartorius, (*c*) the adductor longus, (*d*) the adductor magnus, (*e*) the gracilis, and (*f*) the hamstrings. 3. **Vessels**—(*a*) The femoral vessels (about this point these will be found at the inner side of the posterior flap); (*b*) the profunda vessels with the perforating branches (these will also be found in the posterior flap, close to the posterior surface of the femur); (*c*) the long saphenous vein, and branches of the external circumflex; and (*d*) the comes nervi ischiadici. The position of the femoral will vary with the point of section; for, as has already been pointed out, the vessel as it passes down the thigh gradually inclines from the anterior to the posterior aspect of the bone, so that it may be found at some parts in the inner side of the anterior flap. 4. **Nerves**—(*a*) The great sciatic; and also small branches of—(*b*) the obturator, (*c*) the anterior crural, (*d*) the small sciatic, and (*e*) the external cutaneous. 5. The femur.

AMPUTATION AT THE HIP JOINT.

As **hæmorrhage** is one of the most serious dangers of this operation, various measures are employed, or have been suggested, to overcome this danger:—

1. **Lister's or Pancoast's Aortic Tourniquet.**—Previously this was the method usually adopted, but, as Lister himself points out, it has two defects—1. On account of the occasional deviation of the arota from its median, or almost median, position, the adjustment of the pad, and its retention when adjusted, is rendered a difficult matter, and it is apt to slip to one side, and in order to prevent this the constant attention of a very trustworthy and steady assistant is required. 2. The Surgeon, especially if inexperienced and nervous, is apt to screw down the pad too tightly and damage the intestines and peritoneum; a soft hollow sponge placed under the pad will, to a certain extent, prevent this. It is compressed immediately above its bifurcation, a little above and to the left of the umbilicus, as the aorta bifurcates a little to the left and *below* the umbilicus, or on a level with the highest points of the iliac crests.

2. **Esmarch's Elastic Tourniquet, applied to the Aorta.**—A pad of sufficient size is adapted over the aorta, a little above the highest points of the iliac crests, and pressed down by elastic bands. To avoid circular compression of the body, a narrow piece of board, or some such contrivance, is placed transversely beneath the back and made to project beyond the sides of the body; lateral notches are made in it, or hooks are attached to it, at a sufficient distance to protect the sides from compression, and at the same time to serve to fix the elastic bands. ESMARCH himself recommends, in absence of any other instrument, the following plan:—A common roller bandage, about two and a half inches wide and eight yards long, is to be rolled round a stick about the thickness of the thumb, and nine inches long. The pad thus formed is held in proper position by the ends of the stick, while several turns of elastic bandage are passed round the body, so as to press it forcibly against the spine. An assistant keeps the pad in proper position by means of the stick. An objection to this plan (and all plans) of elastic compression is, that should the patient vomit, cough, or struggle, the forcible contraction of the abdominal muscles lifts the pad from the arota and relaxes the compression.

3. **Esmarch's Elastic Tourniquet, applied to the Extreme Upper Part of the Thigh.**—The limb is emptied of blood by vertical elevation for a few minutes, and then an elastic band, strong enough to require the whole strength of the Surgeon to stretch it twice its length, is applied. A piece of bandage is first laid upon the middle of the groin in the line of the limb, and a similar piece placed behind, well below the great trochanter, over which the tube is to be applied. These are to be held by an assistant, who thus prevents the band from slipping downwards over the flaps during disarticulation; the assistant must be warned not to pull too hard lest he stretch the elastic band and thus raise it off the vessel. The scrotum being held aside, the middle of the tube is then placed against the perineum, between the anus and the tuber ischii, and the ends pulled forcibly and crossed as high above the trochanter as possible, and afterwards carried round the body immediately below the iliac crests. If the elastic band is applied firmly enough, it is not necessary to have a pad over the

artery. The front part of the band passes parallel with Poupart's ligament and compresses the artery against the pelvic bone, the posterior turn runs across the great sciatic notch and compresses the vessels passing through it—especially the sciatic and gluteal. This is the method chiefly to be recommended in what is known as JORDAN'S amputation at the hip joint, or its modifications.

4. **Davy's Lever.**—This is used to compress the common iliac artery, as it lies in the groove between the last lumbar vertebra and the psoas muscle. It is a smooth, round, wooden "lever," shaped like a poker, and about two feet long. Two ounces of olive oil are first injected, and the lever is then passed into the rectum sufficiently far to permit its point to press the vessel at the spot mentioned, while the other end is carried towards the thigh of the opposite side and its handle raised, when it acts as a lever of the first order, the anus being the fulcrum. **Two precautions** are necessary in the use of this instrument—1. It must not be used where the coats of the rectum are diseased, as it may easily perforate them and lead to a fatal result. 2. In cases where the meso-rectum is abnormally short it may be impossible, without unnecessary force, to compress the artery on the right side.

5. **By a Steel Skewer.**—"A long sharp-pointed steel skewer is passed across the upper part of the limb well behind the great vessels. A piece of india-rubber tubing is applied in the form of figure-of-eight, so as to constrict the parts on the posterior aspect of the limb, and then a separate piece of tubing is applied so as to constrict the textures on the anterior aspect, so that the circulation is thus completely commanded" (SPENCE).

6. **Digital Compression** of the femoral artery as it lies on the ilio-pectineal eminence. The assistant stands on the side of the patient on which the vessel is to be compressed, and grasps as much of the limb as possible with both hands, fixing the tips of the fingers of the one hand below the adductor muscles, and those of the other on the posterior border of the great trochanter, while the thumbs are placed one above the other over the vessel as it lies on the above-named prominence of bone. In the antero-posterior flap amputation this assistant must be prepared to follow the knife into the first incision and grasp the flap firmly, so as to compress the femoral artery before the knife cuts its way out.

Anterior and Posterior Flaps *(long anterior and shorter posterior).*—The patient must be brought well forwards upon the end of the table, so that the nates project beyond it, and he is further to be steadied by strong bandages—one passed between the sound thigh and the perineum and attached to the upper end of the table; another is to be carried across the pelvis to the lower end, and the sound limb is to be tied to a leg of the table. Three special **assistants** are required—No. 1 has to take charge of the aortic tourniquet; No. 2 compresses the femoral artery against the brim of the pelvis, and follows the knife and secures the artery in the anterior flap; and No. 3 takes charge of the limb. A long amputating knife, with a blade at least twelve inches long, is necessary, and it is well to have a pair of lion forceps and periosteum elevators at hand. The doubtful advantages of this method are its simplicity, ease, and rapidity of performance, and, should the patient survive, a shapely stump. Formerly rapidity of execution was chiefly trusted to, to diminish the risk of shock and loss of blood. In many cases the rapidity was surprising; the late Professor SPENCE states that he has completed disarticulation in one case in *ten seconds*, in another in fifteen seconds, and even in complicated cases in less than thirty seconds! The **landmarks** in the operation are the *tuber ischii* and the *anterior superior iliac spine.* In operating upon the *right* leg, the operator should stand on the *inner* side of the limb; while, if operating on the *left*, he ought to stand on the *outer* side—*i.e.*, he always stands on the left side of the limb to be removed. On the **left side,** the knife is entered about two finger-breadths below the anterior superior iliac spine (or almost midway between it and the great trochanter), and carried deeply through the limb, behind the vessels and obliquely across the joint, opening the capsule if possible. Keep the back of the knife *parallel with Poupart's ligament*, and bring its point out just in front of the tuberosity of the ischium, or immediately below (as the patient lies on the operating table) the ridge formed by the projecting edge of the adductor longus, taking care not to transfix the scrotum, or the opposite thigh, at the same time. The knife should be passed close to the head of the femur, with its edge turned obliquely towards the joint; this will greatly *facilitate* division of the capsule during the first transfixion. If

the **right leg** is to be removed, the point of the knife must be entered where it comes out on the left side; that is, it must be entered just above the tuberosity of the ischium, and brought out midway between the anterior superior iliac spine and the great trochanter. The remaining steps of the operation are the same as on the left side. Everything being ready, the **assistant** who has charge of the leg, *flexes it slightly on the abdomen, and, at the same time, abducts it a little and rotates it slightly inwards.* The knife is then entered as already explained, and the anterior flap cut downwards and forwards for about six or eight inches, taking care to keep the flap broad at the point by carrying the knife close to the bone for a considerable distance, and then bringing it out abruptly at the last; the assistant must on no account extend the limb till the flap is completely cut, and, further, the assistant who has charge of the anterior flap with the femoral artery, must not raise the flap at all nor compress it *laterally* till the knife has cut its way out. Make the anterior flap as broad as possible; to facilitate this, place the palm of the left hand below the limb and gently raise up the great muscular mass on the inner side and behind. The leg **assistant** now *forcibly abducts, extends, and rotates the limb outwards,* while the Surgeon opens the capsule of the joint with the point of the knife, and allows the head to spring out of the cotyloid cavity, and then divides the *ligamentum teres.* The assistant next allows the leg to hang downwards, so as to bring the head of the femur away from the cavity and put the posterior part of the capsule on the stretch, which the Surgeon also divides with the point of his knife. The **assistant** again *places the limb in the extended position, in a line with the body, and rotates it well inwards,* so that the great trochanter shall not arrest the knife. The operator then makes the posterior flap by carrying the knife downwards and backwards, forming a flap about four inches in length, or about half the length of the anterior. The arteries in the posterior flap (gluteal and sciatic) often bleed freely and should be at once compressed by a dry flat sponge and tied first, provided the assistant who has charge of the femoral artery has a good hold and is trustworthy. Mr HEATH advises the operator to stand on the *outer* side of the limb in all cases. His objections

to transfixing the *right* leg from the inner side are—(1) The danger of pushing the knife through the obturator foramen into the pelvis; (2) the operator is very much in the way of the assistant who manipulates the limb; and (3) the chances of being bespattered with blood, and the certainty of intercepting the view of bystanders.

Single Anterior Flap.—A single anterior flap is cut as in the last operation, eight or ten inches long; the absence of a posterior flap favours drainage. The different positions and manipulations are exactly the same as in the previous operation, only the knife is carried straight backwards without making a posterior flap.

Lateral Flaps.—The external flap is raised by dissection; the internal is cut by transfixion. The angles where the flaps meet are—In *front*, the centre of the groin, just external to the femoral vessels; *behind*, just in front of the tuberosity of the ischium. Before making the flaps the skin should be pulled well upwards, and they should be about three inches in length or more, the external one reaching to a point about a hand's-breadth below the great trochanter. The external one is then dissected upwards to the level of the upper border of the great trochanter, when the bone is disarticulated and the knife inserted into the anterior angle, passed backwards close to the inner side of the neck of the femur, and brought out at the posterior angle, and a flap, equal in length to the external, formed. The vertical incision favours drainage, but it also favours inoculation of the discharges and wound with germs from the genital and anal passages. Another advantage is that the vessels are cut last—the external flap being raised, and the head of the bone dis articulated before the inner flap is made. In disarticulating, forcibly adduct the limb. The position of the limb during the operation resembles the antero-posterior flap method, the leg being held with the buttocks projecting beyond the edge of the table, and the slight differences in the manipulations will readily suggest themselves. For the inner flap a transfixion knife, with a blade a foot long, is employed; for the external, a shorter one may be used.

Skin Flaps.—As in other cases of malignant disease of joints, this method may also be adopted at the hip. Make the skin flap

sufficiently long, as the skin is very contractile—six to eight inches both front and back. The great objection to this plan is that all the irregularities have to fill up by tedious granulation, and may not be thoroughly healed for years.

Furneaux Jordan's Amputation.—The soundness of the principles of this method has already been fully demonstrated in practice, and at the present time the whole question of amputation at the hip joint has been revolutionised. The days of the old classical flap methods are numbered. But in the case of malignant disease, with infiltration of the soft parts, JORDAN'S method cannot be adopted, and skin flaps must be used instead. The **principles** of the method are—1. To cut across the limb where it is smaller and further removed from the trunk, and to interfere as little as possible with the bulky soft parts at the *upper and inner part* of the thigh. 2. Ligature of all the blood-vessels on the face of the stump. 3. To enucleate the femur by an incision through a part where it is most thinly covered by soft textures, and where the blood-vessels are small and few, keeping the edge of the knife cutting on the bone as it is being cleared on the inner side. Either the one or the other of these two plans may be adopted—that is, we may either divide the soft parts circularly low down the thigh, tie all the vessels, and then dissect out the bone through a long incision on the outer aspect of the limb, or else dislodge the head of the femur first from the acetabulum, separate the shaft from the soft parts, and cut across the soft parts last and low down—according to the taste of the operator. Probably the best way is to divide the soft parts and bone circularly low down, then tie all the vessels, turn the patient over to the sound side, and remove the head and upper part of the shaft of the femur through the vertical incision on the outer aspect of the limb. The circular division of the limb is accomplished by means of a large transfixion knife; for the rest of the operation a knife somewhat resembling the knife used in SYME'S amputation will be found most convenient. A probe-pointed knife is sometimes used, though this is unnecessary, provided the operator keeps the edge of his knife close to the bone. In this case the leg is held projecting from the buttock over the edge of the table, slightly flexed or horizontal. To prevent the patient moving during the progress of the operation, he should

[illegible] to the sound side and maintained in that position from the very beginning of the operation, the Surgeon will be able readily enough to perform the circular amputation in that position. Another assistant pulls the integuments well upwards, while the Surgeon encircles the limb by one sweep of the knife through the skin, fat, and fascia; the skin and fat are then dissected upwards a little way, and the muscles divided by another circular sweep of the knife down to the bone, which is sawn on a level with the muscles. Some divide the skin and muscles at the same level, but it is better, I think, at any rate in muscular limbs, to retract the skin and subcutaneous fat a short distance first. A neater stump will be obtained by shaping the skin incisions in the form of two slightly convex flaps. It will be observed, therefore, that the plan adopted is a combination of the flap and circular methods. All the vessels are then secured, and the bone disarticulated and dissected out through the vertical incision.

After the limb has been removed by the circular amputation, the bone is held by a lion forceps fixed in the medullary cavity, and the muscles about the great trochanter divided, first behind and then in front, and the capsule, especially the strong anterior part, opened, and thereafter air admitted into the acetabulum, either by dividing the transverse ligament, and the other structures in that neighbourhood, or else by forcing the point of the knife into the joint through the cotyloid ligament. By this means we get rid of the atmospheric pressure which keeps the bones in contact. The muscles attached to the shaft and small trochanter are next divided, and then, by forcible abduction, the bone will readily spring from its socket; the ligamentum teres and any remaining soft tissues are divided, and the bone removed. During these manipulations an assistant must support the large muscular mass on the inner side of the thigh with one hand, while with the other, as necessary from time to time, he holds the lion forceps, and gently rotates the bone so that the operator may find out the structures still attached to the bone. The operator must cut close to the bone, especially in freeing it on the inner side, so as not to disturb the muscular mass beyond it. The vertical incision should be made towards the posterior part of the great trochanter for two reasons: (1) because there the blood-vessels are least

numerous and smallest, and (2) because of more easy access to the numerous and powerful muscles towards the posterior aspect of the joint.

As this operation is usually performed for late hip disease, the disarticulation, as a rule, is easy. Should, however, any difficulty be experienced, the bone should be adducted to the greatest possible extent, and the great trochanter seized with a pair of lion forceps and dragged forcibly outwards. It will be observed that this method of amputating at the hip is, as nearly as possible, the same as that adopted by Professor Spence at the shoulder.

In the other case the patient is at once turned to the sound side, and a free vertical incision is made along the outer side of the thigh from the top of the great trochanter, six inches or more in length. Dislodge the head of the femur, and then separate the upper part of the shaft from the soft structures by a few longitudinal strokes of the knife, the edge of which must be kept close to the bone; the bone is thus cleared as far as may be deemed necessary. It is next replaced in its bed till the soft parts are divided at any level thought desirable by circular sweeps first through the skin and then the muscles; then secure all the bleeding vessels, and closely stitch up the lower part of the wound and insert a drainage tube at the lower and outer angle. It is always advisable to save the periosteum if possible, so that the muscles may still retain their attachment, and besides, a central rod of bone may be produced, which will render the stump firm, and give the patient some amount of control over an artificial limb. It must be remembered, however, that in the later stages of hip disease the periosteal hæmorrhage may be free and difficult to check.

Sir Joseph Lister makes a longitudinal incision about eight inches long at the posterior part of the great trochanter, and then makes two crescentic incisions round the limb through skin and fat, which meet on the inner side of the limb at a point an inch or two lower down than the extremity of the outer longitudinal cut. The semilunar flaps thus marked out are dissected up as in the modified circular operation for two inches or so, after which the muscles are divided where they are exposed (see Fig. 59).

The **advantages** of JORDAN's method are—1. The cut surface is less; the manner in which the shaft of the femur is separated from the soft parts only causes a superficial wound on the outside of the stump: there are no surfaces as when flaps are formed (SPENCE). 2. The large nerves are cut further from the trunk. 3. The shock is immensely diminished. 4. It can be kept aseptic, as the wounded surface is further from the rectal and urinary passages. 5. Union should be more rapid. 6. It may be done subperiosteally. 7. There is no need for hurry on account of any danger from hæmorrhage; there is no deep or large cut surface to furnish much hæmorrhage. 8. The vessels are cut transversely, and not obliquely as in the flap methods. 9. The stump is much longer than in the ordinary flap operations, and it is more easy therefore to fit an artificial limb to it; and, should the subperiosteal plan be adopted, the stump is firm and the patient will possess a considerable amount of power over the artificial substitute. 10. In cases of doubt the Surgeon can make the vertical part of the incision first, examine the joint, and, if too bad for excision, convert it into a "JORDAN," just as in SPENCE at the shoulder, and CARDEN at the knee joint. The only **disadvantage** is that it is more difficult and tedious to perform than the ordinary flap amputation.

In Mr BECK's hands the method assumes the form of the **oval** or "**racket-shaped**" amputation, which he performs thus:—The patient is placed on his sound side with his hips close to the edge of the table; the sound thigh is to be flexed as far as possible, and secured in that position by two bandages, one attached to the thigh immediately above the knee with a clove hitch, the two ends of which are passed round the patient's neck, and under the arm of the same side, and firmly knotted; this maintains the flexed position and steadies the trunk. The other is also passed round the sound thigh and secured to the leg of the table, beneath the patient's *head*, in order to prevent him slipping down during the operation. Secured thus, his body is further steadied by an assistant placed opposite the shoulders; another **assistant** has charge of the thigh, which he grasps above the knee and holds slightly adducted, and a third, standing opposite the Surgeon, has to grasp the femoral artery by thrusting *his* hand into the wound and securing it between his fingers and

thumb before it is divided. The **Surgeon** stands behind for the right thigh, and in front for the left, so as to grasp the flaps with his left hand; he should further be provided with a moderate-sized amputating knife, the blade being about six inches long. On the *right* side the incision is commenced about two inches above the great trochanter, and carried down to the bone and along the shaft for six or seven inches below the trochanter, and at this point the incision is made to bifurcate, passing respectively forwards and backwards for about two inches, so as to mark the point where the "oval" is to surround the thigh. The assistant now abducts the limb, and the operator pushes his thumb into the slit made in the two smaller glutei, which he stretches, and with the point of the knife separates the muscles from the trochanter and upper part of the femur, first in front and then behind. The assistant next forcibly adducts the limb, and at the same time tries to lift the head of the femur out of its socket, by placing one of his hands on the inner side of the thigh, as high up as possible. The Surgeon then opens the joint by making a free cut in the line of the first incision, so as to slit open the capsule and divide the cotyloid ligament, and then carries the knife along the posterior attachment of the capsule. The head of the bone should now spring out of its socket, but if not it may be dragged out by seizing the great trochanter with a pair of lion forceps; the round ligament is next divided. The anterior part of the capsule is then cut, the knife passed over the head of the bone, and the assistant then grasps the trochanter and pulls the bone forcibly out of the wound, while the operator holds the soft parts out of the way with his left hand, and passes his knife along the inner side of the femur, freeing the bone from the soft parts as low as required. All this time the limb must be in a position of extreme adduction. When the bone is cleared as far as necessary, it is replaced in its bed, and the limb brought into a straight line with the trunk, and the Surgeon completes the skin oval and dissects up the skin, fat, and fascia, for two or more inches, especially in very muscular limbs; another assistant then places his hand in the wound and grasps the femoral artery, while the muscles are divided and the leg removed. If preferred, the skin oval may be completed and dissected up the necessary

distance, before the head of the bone is dislodged. On the *left* side the only difference in the operation is, that the straight incision is made from below upwards.

The late Professor Spence, for some time before his death (1882), used this method in special cases—cases of amputation after failure of excision in hip-joint disease; he used the steel skewer and elastic bands to control the vessels. He thus describes the operation:—" The Surgeon, with a short knife such as that used for amputation at the ankle, cuts from the outside directly upon the great trochanter and shaft of the femur to an extent sufficient to form a covering. The limb is then brought across the opposite one, so as to tilt out the upper part of the femur, and then, keeping the edge of the knife cutting on the inner aspect of the bone, it is cleared on its internal side. Then all the operator has to do to complete the amputation is to cut through the soft parts, at the lowest point where they are separated from the femur. This may be effected by one circular sweep of the knife, but a neater result is obtained by shaping the margins slightly convex. The great vessels are tied where they are divided by the circular incision; then the anterior india-rubber band is removed from the limb, and any vessels which bleed are secured; next, the posterior compressing band is taken off, the skewer withdrawn, and the bleeding vessels tied. As to arrest of bleeding, it will be observed that there is no deep or large cut surface to furnish much hæmorrhage. The great vessels are divided in the circular division at the extremity of the stump, and the manner in which the shaft of the femur is separated from the soft parts causes only a superficial wound on the outside of the stump. There are no surfaces, as when flaps are formed."

In amputations through the hip joint the following is a list of the **chief Structures divided**—1. The integumentary coverings. 2. **Muscles**—(*a*) Pectineus, (*b*) the three adductors, (*c*) the gracilis, (*d*) the sartorius, (*e*) the tensor fasciæ femoris, (*f*) the upper part of the quadriceps extensor cruris (rectus and part of vasti), (*g*) the obturator internus and the two gemelli, (*h*) the obturator externus, (*i*) the pyriformis, (*j*) the three hamstrings (the biceps, the semi-tendinosus, and the semi-membranosus), (*k*) the three glutei muscles, (*l*) the quadratus femoris, and (*m*) the psoas and iliacus.

3. **Vessels**—(*a*) The long saphenous vein, (*b*) the femoral vessels (in the anterior flap), (*c*) the profunda vessels and the external circumflex, (*d*) the sciatic vessels, (*e*) the gluteal vessels (the gluteal and sciatic vessels are found in the posterior flap), (*f*) the internal circumflex (close to the inner side of the acetabulum), and (*g*) the upper perforating will also be cut. 4. **Nerves**—(*a*) The branches of the anterior crural, (*b*) the branches of the obturator, (*c*) the great sciatic, (*d*) the small sciatic, (*e*) the external cutaneous, and (*f*) the branches of the superior gluteal. 5. **Ligaments**—(*a*) The capsular ligament, (*b*) the ligamentum teres, and (*c*) the ilio-femoral band.

RÉSUMÉ :—I propose now to give a short *résumé* of what I believe to be the best methods of procedure, to act as a kind of guide to the student, who must, to a certain extent, be guided by the advice of others till he is old enough to judge for himself:—

THE FOOT.

In all operations on the foot and ankle, the long flap—the one that bears the greatest amount of pressure afterwards—should be taken from the sole, since the tissue here has been accustomed to bear weight.

1. **Terminal Phalanx of Great Toe.**—A long plantar flap, made in the same way as in the terminal phalanges of the fingers, with or without a short dorsal flap.

2. **An Entire Toe.**—The "oval," the straight part of the incision being dorsal: in the case of the big toe take plenty of tissue from the side of the proximal phalanx to cover in the large head of the metatarsal bone, making the inner part of the oval larger than the outer; do not remove the head of the bone as this will destroy the tripod, and a study of the laws of Natural Philosophy teaches us that a body can stand most securely on *three* points, and on three points only. The same remarks apply to the little and other toes.

3. **For an Entire Toe with its Metatarsal Bone.**—The "racket-shaped" incision, the long straight part of the incision being dorsal, and the oval part at the level of the metatarso-phalangeal articulation.

4. **Region of the Tarso-Metatarsal Articulation.**—In cases of *accident* dissect up a sufficient sole flap with, if possible, a short dorsal, and saw the bones across at any convenient point irrespective of articulations, or perform a HEY; for *disease* of the tarsal bones, as a rule, and in cases of smash in the region of the median tarsal articulation, go to the ankle joint at once. There is, however, one exception, and that is disease limited to the os calcis; in this case the carious and tubercular matter may be scraped away with every hope of a satisfactory result.

5. **The Ankle Joint.**—SYME, by the heel flap, or MACKENZIE by large internal calcaneal flap. The numberless other plans and modifications need scarcely be considered, as the stumps left do not bear the weight of the body better, nor are they so well adapted for progression, whatever they may be for the purposes of the instrument-maker.

THE LEG AND THIGH.

1. **Just above the Ankle.**—The SYME flap may be utilised for two and a half inches from the lower end of the tibia. If this cannot be so utilised, then use a long anterior flap with a short posterior, or in some cases a TEALE may be adopted.

2. **Through the Calf and at the "Seat of Election."**—The method described in the text as LISTER's, or else the "modified circular," the skin flaps being anterior and posterior, not lateral, except in cases of necessity.

3. **At the Knee Joint.**—A long anterior with a short posterior flap, the ends of the flaps being almost square, or STEPHEN SMITH's "hooded flaps."

4. **Through the Condyles of Femur.**—CARDEN or GRITTI.

5. **At the Lower Third of the Thigh.**—SPENCE's amputation, the "modified circular," or, occasionally, a TEALE.

6. **The Middle Third and below the Trochanter.**—The method described as LISTER's, or the "modified circular."

7. **The Hip.**—The method associated with FURNEAUX JORDAN's name.

CHAPTER XVIII.

EXCISION OF JOINTS.

I. **Excision may be required for**—1. **Injury**, as bad compound dislocations, fractures into joints, more especially gun-shot injuries of the head of the humerus, bones of the elbow joint, and head of femur. 2. For **Disease** of various kinds—(*a*) To *remove the diseased part* in cases where amputation is not justifiable, as in some cases of hip joint disease, and disease of the temporo-maxillary articulation; (*b*) to *save life* where the patient is being exhausted by the discharge and pain, and unless relieved will probably die; and (*c*) merely to expedite recovery and save the patient months or years of suffering. 3. For the **Results of Disease or Injury,** as in osseous ankylosis of the elbow, or of the knee joint in a bad position.

II. **The Objects aimed at are**—1. Complete removal of the diseased part. 2. To leave a useful limb—in the upper extremity, by securing mobility; in the lower, by procuring ankylosis, in order to give a firm basis of support. This is subject to occasional variation to suit the special occupation of the individual—*e.g.*, a house-painter requiring his arm fixed in the straight position, or a turner requiring his knee fixed at a right angle so as to allow him to work the treadle (Bryant).

III. **Excision** *versus* **Incision.**—In cases where there is no evidence of disease of the bone, but the joint is full of pus, then a free incision and drainage is the proper course; this relieves tension and may cure the disease, but may leave a stiff joint. Sometimes incision and scraping or clipping away the gelatinised synovial membrane and other soft tissues, scraping carious cavities and surfaces with a sharp spoon, thorough washing with a solution of bichloride of mercury and insufflation of

iodoform, with free drainage, and strict antiseptic dressing, and rigid splints to insure perfect *rest*, may give a very good result—*e.g.*, in the ankle joint. This operation is known by the name of "**Arthrectomy**," to distinguish it from the operation of excision, properly so called: it is also called "erasion of the joint." It is often adopted in the case of the knee, and the incisions used may be lateral, or resemble those used for the operation of excision, after the limb has been rendered bloodless by ESMARCH's method. Should this method be adopted, let the incisions be made in such a way that they will not interfere with subsequent excision, should that be found necessary.

IV. **Incision** *versus* **Expectancy.**—1. *Consider the possibility of Natural Cure.*—A large and important joint ought not to be rashly excised, if such a possibility exists. It is especially advisable to wait, in the upper classes, who can procure all the benefits of the best medical skill and attendance, good food and good nursing; with hospital patients, however, the case is different, and probably excision will prove the kindest and best treatment. It is also advisable to wait in cases where the disease is *local* and the general health good. 2. *Consider the possible Result of a Natural Cure.*—The great drawback to the "expectant" plan is the prolonged course of the disease, perhaps for months or years, and often at the end of that time the patient is little better, or even worse, than had an operation been performed, and from which he would probably have recovered in a few weeks. Hence we must carefully place before the patient the two possible alternatives—speedy cure but with the risk of the operation, opposed to prolonged illness and risk of exhaustion, and in the end a useless limb. In the case, however, of the wrist joint, it is a little different (see "Excision of Wrist").

V. **Excision** *versus* **Amputation.**—1. *The Comparative Risk of the Two Operations.*—Excision makes a larger wound, and therefore a greater strain on the constitution and a larger surface for septic absorption; hence, in advanced disease of the joint, with abscesses around it and discharging sinuses, it is better to amputate, as it would be a difficult matter to make and keep the wound aseptic. 2. *As regards the Joint affected*, and the advantages of the limb left, over an artificial substitute.—Excision is safer than

amputation at the *Shoulder;* at the *Elbow*, the danger is nearly equal; but the probability of saving a useful arm and hand throws the weight on the side of excision. So also at the *Wrist*, excision is to be preferred to amputation. At the *Hip*, excision is very much safer. At the *Knee*, excision was formerly more dangerous than amputation, but thorough drainage with the present antiseptic methods of treating wounds have done much to lessen the mortality. At the *Ankle*, amputation (SYME's) is a less severe operation, and will probably give the most satisfactory result in every way. Hence, excision of the ankle is but rarely performed, except, of course, in cases of injury, where the broken fragments may be removed, the joint rendered thoroughly aseptic, and the rest left to Nature. In the upper extremity, therefore, usually excise—using every possible endeavour to preserve a movable elbow, wrist, and thumb; in the hip, wait—or, if that is not advisable, excision is immensely preferable to amputation. But sometimes amputation is necessary in the case of prolonged and exhausting disease to give the patient a chance for his life, and the present improved method of amputating the hip joint has robbed that operation of many of its former most serious risks. 3. *As regards the Disease.*—Excision should never be performed for malignant disease, nor in advanced cases of gelatinous degeneration, with abscesses round the joint, and pus burrowing up and down the limb. It should not be done, either, in the *acute* stages of the disease; in such a case, rather trust to a free incision with antiseptic precautions and drainage. It is chiefly indicated in disease of the cartilage, and limited disease of the bone. "The most appropriate cases for excision of joints are those of chronic disease of all the tissues (*white swelling*), in which the bones are probably not affected to any great depth" (HOLMES). It has been occasionally performed for chronic rheumatic arthritis; but in this disease, to say the least, it is not a *necessary* operation in the sense of saving life, and it should not therefore be pressed upon the patient, and besides it is rare to find a *single* joint affected with this disease. It is also performed for cario-necrosis of the articular ends of bones, but the loose part may simply be removed and the joint left to ankylose—except in the case of the elbow, where ankylosis is objectionable. In diffuse caries of the hip

wait, even though slow, unless other indications point towards excision or amputation. When the soft structures only, round the joint, are affected, excision is very rarely required, as a useful limb will probably result without operation of any kind. 4. *As regards the General Health and Social Position of the Patient*—in reference to the comparative risk of a long or short after treatment; whether or not he is worn out by exhausting disease; and also, if free from constitutional taint such as struma, syphilis, etc. Consider also the facilities for after treatment, and the time and attention required—the knee joint, for example, will require great care and repose for many months; also the temperament, whether irritable or otherwise.

VI. **A Typical Case.**—Where the Surgeon may reasonably hope for a successful result, may be regarded as something like the following:—1. *The Disease should be Limited.*—This is especially necessary in the lower extremity, as removal of a considerable portion of the bones here would render the limb less useful, or altogether useless, and would entail a severe operation. Further, in young persons, unless the disease is limited, the epiphysis will be interfered with and result in arrest of development of the limb. In the upper extremity, however, length and strength are of less consequence. 2. *The Patient should be Constitutionally Healthy*—not worn out by cachectic conditions of any kind, or waxy disease of internal organs.—Under these conditions amputation would be safer. 3. *The Joint affection should be the result of Accident*, and not due to constitutional taint. 4. *The Disease should be Chronic.*—Disease should not be interfered with during the acute stage, because—(*a*) One cannot foretell the probable natural result as the disease subsides. It is possible that as useful a limb will be left by Nature as the Surgeon could hope to obtain by excision. Secure absolute rest, drain if necessary, keep in proper position for ankylosis, and wait. (*b*) Another objection to operation during the acute stage is the risk of setting up septic inflammation of the medullary cavity, or cancelli, with the usual results of osteo-phlebitis, thrombosis, septic embolism, pyæmia, and death. 5. *The Soft Parts around the Joint should be Healthy.*—They should not, for example, be permeated by discharging sinuses. Should they be much infiltrated

and disorganised it would be useless to hope for healing of the wound. This has especially to be considered in the case of the knee and ankle. In other cases—the elbow, for example—the incision may be made so as to include the different sinuses, even though not made in the orthodox position and direction; sometimes also the sinuses may be used as drainage apertures, after freely scraping them with a sharp spoon and brushing them with a solution of zinc chloride (20 to 40 grains to the oz.) or some other antiseptic. 6. *The Patient must not be too young or too old.*—The most suitable age is from twenty to thirty. If too young, even though other conditions are favourable, the epiphysis might suffer, and the development of the limb be arrested to a great extent in consequence, as it is at this part that the development of the bone in length is mainly dependent. In reference to this, Mr HUMPHRY has pointed out that all epiphyses are not of equal importance; he states that the upper epiphysis of the humerus and tibia, and the lower epiphysis of the femur and radius are the most important as regards the growth in length of the respective limbs. If too old, the patient's constitution is unable to bear up against the severity of the operation and the protracted convalescence. 7. The Surgeon should have *proper means* at his disposal *for after treatment*, and a restful, trustful, hopeful patient.

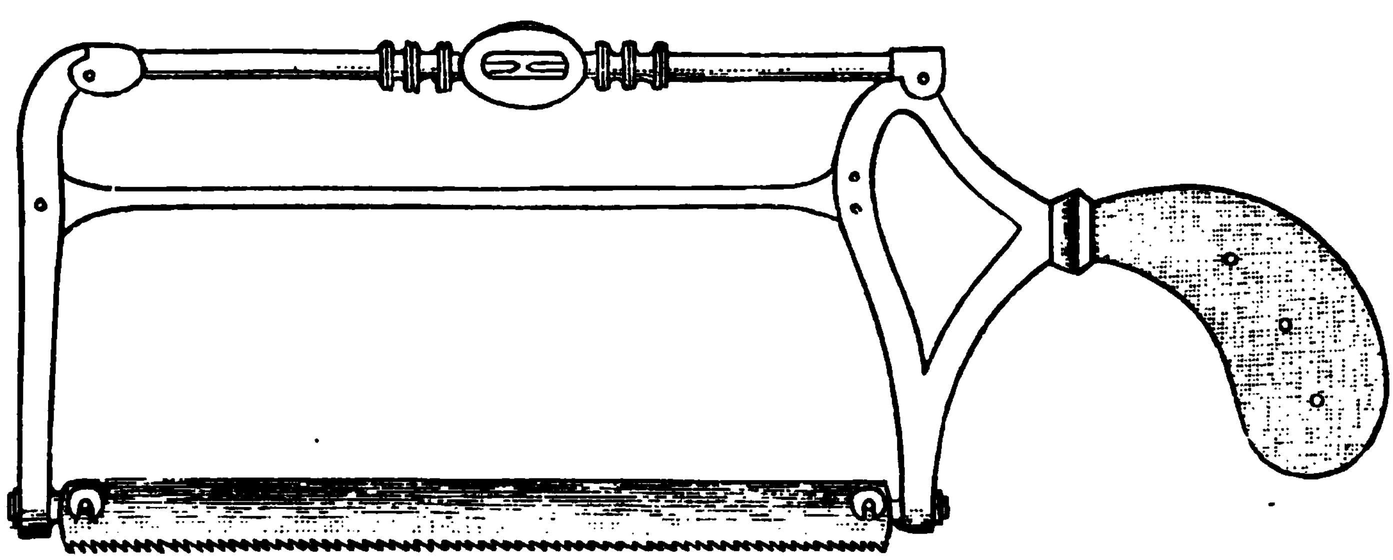
VII. **In Performing the Operation.**—1. Make the *incisions* parallel with the axis of the limb, so that the cicatrix will not interfere with the movements of the joint afterwards; again, by making the incision thus, we will usually avoid dividing important structures, as blood-vessels, nerves, and tendons. At the same time the incision must be sufficiently *free* to expose the parts to be removed. In cases where a movable joint is the object, division of muscles and tendons must be avoided as far as possible. 2. *Remove as little of the bone as possible*, consistent with the object in view. The gouge may be used to scoop out carious cavities, in preference to making a complete transverse section of the bone again. At the same time, if too little bone be removed in the case of the elbow joint, the risk of bony ankylosis is very great (SPENCE). But in the case of the knee joint, where the object is ankylosis with the least possible amount of shortening, then remove as little as possible. 3. In cases where a movable joint is the object,

save the periosteum and capsule of the joint, provided they are healthy. 4. In cases of "pulpy disease" of the synovial membrane, all the diseased textures must be carefully *scraped away* with a sharp spoon, and all sinuses must be very freely scraped and asepticised and provision made for thorough drainage, and the whole dressed with strict antiseptic precautions. 5. The *special splints*, and attention to secure movement or absolute rigidity, will be mentioned under the special excisions.

VIII. **Instruments Required.**—I will only mention the special and more important instruments necessary in this list. 1. *Scalpels and Bistouries*, thin and stout-bladed, strong-backed, and sharp-pointed, and occasionally a blunt-pointed one is useful—the sharp-pointed are used for making the incisions, and the blunt-pointed

Fig. 61.

BUTCHER'S SAW.



one used afterwards, as in shoulder and hip excisions. 2. *Saws of various kinds*—(*a*) BUTCHER's, which has a narrow blade that can be adjusted to any angle, so that it runs easily and in any direction; it is especially suitable for the elbow, or in cases where it is desirable to cut the bone obliquely and where the space is limited (Fig. 61). (*b*) A broad-bladed, strong, movable-backed amputating saw, such as FERGUSSON's, should be preferred in excision of the knee joint, where the bones are easily reached, and a broad slice has to be removed in a special direction. (*c*) A chain saw is occasionally of use in dividing deep-seated parts, as in the hip joint. (*d*) A "key-hole" saw. 3. *Broad curved Copper Retractors*. 4. *Gouges, to scoop out* carious cavities after section, and thus economise

length of bone. 5. *Lion Forceps* (FERGUSSON'S), to hold firmly the piece of bone to be sawn off. 6. *Cutting Pliers and Gouge Forceps.* 7. *Periosteum Elevators.* 8. *Excision Director*, in cases where the bone cannot be turned out of the wound. 9. VOLKMANN'S *Sharp Spoon.* 10. ESMARCH'S *Elastic Tourniquet*, to prevent bleeding during the operation. To this list might be added—artery forceps, dressing forceps, sutures, needles, dressings, splints, awl for "wiring" bones, drainage tubes, etc.

In operating upon the **dead body**—(1) A suitable knife, (2) retractors, (3) a proper saw, (4) lion forceps, (5) bone forceps, (6) dressing forceps, and (7) a periosteum elevator, are required. These must all be selected before beginning the operation, and placed on a tray within easy reach of the operator's right hand.

In closing this chapter, let me enumerate the chief local measures at our disposal for the treatment of strumous arthritis, *e.g.*, in the knee joint:—

1. Absolute and prolonged rest of the joint.
2. Arthrotomy, or incision and drainage, where the joint contains pus.
3. Arthrectomy, or erasion—*i.e.*, clipping and scraping away the diseased textures; especially indicated in the young, and where the synovial membrane is the chief seat of disease.
4. Excision, in persons under thirty-five, and if the disease be within reach, and limited.
5. Amputation, in persons beyond thirty-five or forty, or where the disease is beyond the reach of excision, or the patient is manifestly going down hill, as from waxy disease of the viscera.

CHAPTER XIX.

SPECIAL EXCISIONS.

SHOULDER.

Excision of the Shoulder Joint.—Various forms of incisions have been proposed—(*a*) A single longitudinal vertical incision; (*b*) a T-shaped incision; (*c*) a modification of this form, one half of the cross bar being omitted—somewhat like the letter L upside down: these two forms are chiefly used in cases where the soft parts are much infiltrated and non-resilient, and where, consequently, it is necessary to gain more room, which is done by making a short cross-cut at one or both sides of the longitudinal incision; and (*d*) the U-shaped deltoid flap operation.

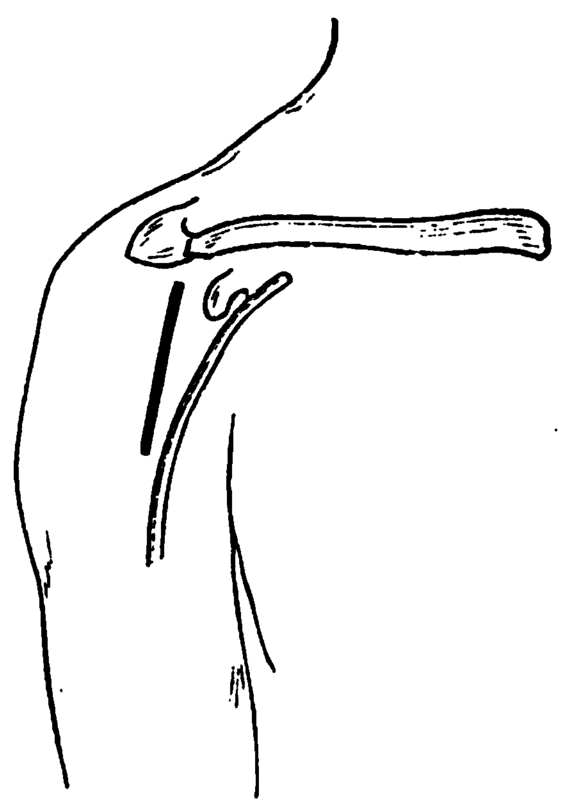
To **check hæmorrhage** during the operation, an assistant may compress the subclavian by a padded key, or ESMARCH's elastic tourniquet may be used. The elastic band is forcibly stretched, and applied round the shoulder, and as high up in the axilla as possible, so as to compress the artery against the neck of the scapula; the upper part of the turn should rest in the concavity at the outer end of the clavicle and internal to the coracoid process in front, and root of acromion process behind. To prevent its slipping during the operation, pieces of bandage should be placed beneath it, both in front and behind, and held by an assistant at the opposite shoulder. Excision may be **required for**—1. *Disease*—as caries of the head of the bone, simple and tubercular, disease of the cartilage, etc. In these cases the glenoid cavity is *secondarily* involved, and will recover without interference, when the head of the bone is removed. 2. *Injury*—as compound and comminuted fractures, gun-shot wounds, etc. 3. *Results of Disease or Injury* rarely demand excision of the shoulder. Many diseases end in ankylosis, either true or false; but for this condition excision

is but rarely indicated—(*a*) Because, on account of the weight of the arm, it usually ankyloses in the best possible position; and (*b*) even when ankylosed in a not very favourable position, the mobility of the scapula to a great extent compensates for the loss of movement of the joint itself; besides, the amount of movement obtained after excision is very often not so great as in cases of ankylosis by disease.

I. **By the Single Longitudinal Vertical Incision** (Fig. 62).—In connection with this incision, it should be noted that the posterior

Fig. 62.

EXCISION OF SHOULDER.



Observe Position of Cephalic Vein.

circumflex artery, which passes round the posterior aspect of the surgical neck of the humerus, though large at first, becomes very rapidly smaller; and therefore the incision should be towards the anterior part of the joint, in order to avoid wounding either the trunk of the vessel or its larger branches, and thus lessen hæmorrhage during the operation. **Position of the Patient.**—He is to be placed on his back, with the shoulder to be excised raised and projecting beyond the edge of the table, and held by an assistant slightly abducted. The **operator** stands facing the patient, and on the same side as the joint to be excised. Begin the **incision** a little to the outer

side of and above the coracoid process, and carry it downwards and a little outwards through the anterior part of the deltoid, immediately external to the cephalic vein, which must not be injured, and the humeral branch of the thoracic axis, for about four inches, down to, but not through, the insertion of the pectoralis major. The incision must go right down to the capsule. By this incision (1) the integumentary structures and (2) the deltoid are divided; before going further, secure the anterior circumflex and the bleeding points with WELLS's forceps. Draw aside the edges of the wound with blunt hooks or copper spatulæ, feel for the bicipital groove, and then make a longitudinal incision through the periosteum and capsule, along the inner side of the groove to the glenoid cavity. The long tendon of the biceps, if healthy, may then be raised from its bed and drawn to the outer side. The assistant then rotates the humerus forcibly outwards, while the Surgeon separates the tendon of the subscapularis and periosteum from the head of the bone with a periosteum elevator. The long tendon of the biceps is now to be shifted to the inner side, and then the assistant rotates the humerus inwards and allows it to fall over the edge of the table, when the Surgeon separates the periosteum and muscles attached to the greater tuberosity—the supra-spinatus, infra-spinatus, and teres minor—in the same way that he separated the tendon of the subscapularis. In cases of disease, where the tissues are much condensed, a small cross incision may be made in the deltoid, just under the acromion process, in order to expose the great tuberosity fully. The assistant next forces the head of the bone up into the wound, by drawing back the elbow and pushing upwards, when the Surgeon separates the posterior part of the capsule with the periosteum elevator, or divides it with a bistoury, keeping in mind the near presence of the posterior circumflex artery and the circumflex nerve, and carefully preserving them from injury; the Surgeon himself then takes the arm from the assistant, pushes the head of bone out of the wound, while the assistant draws the soft parts well aside, and saws the bone by a BUTCHER's saw, with reversed blade, through the surgical neck. In cases where the head of the bone is severed from the shaft by injury or disease, it must be seized with a lion *forceps and* carefully dissected out. As this operation is usually

practised for disease, the periosteum, softened by the inflammatory action, is readily separated from the bone. Should, however, any great difficulty be experienced in doing so, the capsule must be divided close to and on the anatomical neck of the humerus, along with the tendons attached to the tuberosities, by a single firm sweep of the knife as the assistant rotates and lowers the arm. The glenoid cavity is next examined, but it rarely requires to be interfered with at all. If very much diseased, it may be removed by the bone-pliers or dressed with the gouge forceps, either through the incision already made or through a posterior vertical incision, above the posterior circumflex artery. This may seem an unnecessary mutilation, but as a matter of fact it is not so, as this opening can be afterwards utilised for drainage, and besides, the glenoid cavity is much nearer the posterior than the anterior surface. In cases where the glenoid cavity is not interfered with, a counter opening must be made behind for the exit of discharges, since the patient lies on his back; and were no opening made the wound would simply become a huge well of putrescible fluids, and a fit nidus for the growth of putrefactive or pathogenic organisms. To make the opening, bring the arm to the side, into the same position it will occupy during the after treatment, and by means of a dressing forceps (Mr SPENCE used his left index finger) work through the tissues till its point presses against the skin above the posterior circumflex artery; divide the skin over the point of the forceps, push it through, open the blades, seize the drainage tube, and withdraw the forceps, leaving the tube in its proper place. This care is necessary, on account of the presence of the large posterior circumflex artery.

As regards the **after treatment** no special apparatus is required, all that is necessary is to support the shoulder on a pillow for a few days, with a good, long, soft pad, thicker above than below, placed in the axilla to keep the upper part of the shaft outwards, as it is apt to be tilted inwards by the muscles inserted into the bicipital groove—pectoralis major, latissimus dorsi, and teres major—just as in fracture of the surgical neck. The wound is dressed in the usual way and the whole upper extremity bound to the chest. When the patient is able to sit up and move about (which he should be encouraged to do as soon as possible), the arm

is to be supported by a sling, and the elbow allowed to hang freely down (BELL). He may be allowed to move about, the elbow being carefully supported (HOLMES). In any case it must be gradually brought into useful motion, first passive, and then voluntary. In the case of this joint however, even though the parts should unite by osseous ankylosis, it is of little consequence, as the mobility of the scapula compensates for the stiff shoulder joint, and the arm, during healing, naturally falls into the most useful position under the action of gravity. The **advantages** of the longitudinal incision, in this position, are—(1) The deltoid muscle is not injured to any extent, and will therefore be of great service after the wound has healed; (2) the posterior circumflex artery is not divided, except a few of its terminal twigs, and therefore the hæmorrhage is not great; and (3) if the joint is too bad for excision, the wound is easily transformed into a Spence's amputation. The only **disadvantage** is that it is rather more difficult to perform than by the next incision.

After excision the arm can never be raised beyond a right angle; flexion, extension, and adduction are usually free, but rotation is, as a rule, permanently lost. The amount of abduction will necessarily depend on how the operation has been performed; if by the deltoid flap, then it will be greatly diminished. The length and strength of the arm are of little consequence, so long as it is able to be a useful servant to the *hand*, which is the chief point to be considered in all excisions of the upper extremity.

RÉSUMÉ of this operation:—

1. Make the incision so as to avoid the cephalic vein: incision to go at once to capsule or bone, and be four inches long.
2. Open up the bicipital groove and displace the long head of the biceps to the outer side.
3. Rotate outwards and divide the tendon of subscapularis and capsule, by cutting on the anatomical neck of the humerus.
4. Displace the tendon of the biceps to the inner side, let the arm hang well over the table and the elbow be drawn slightly backwards, rotate the humerus inwards and divide the tendons of the supra-spinatus and teres

minor, with the capsule, by cutting directly on the anatomical neck of the humerus.

5. Divide the posterior part of capsule, force head of bone through the wound and remove it by BUTCHER'S saw, with blade reversed.
6. Examine glenoid cavity and do what may be necessary.
7. Make an opening for drainage behind, by dressing forceps and knife, and afterwards dress the wound, fixing the arm to the side.

NOTE.—Mr Spence reversed the steps 3 and 4 of this *résumé*, dividing the muscles attached to the great tuberosity first. He regarded the division of the broad attachment of the subscapularis into the small tuberosity as the *key* of the operation.

II. **By the U- or rather V-shaped Flap,** with the base upwards, from the deltoid. The **incision** is commenced at the posterior border of the acromion process, and carried across the line of insertion of the deltoid, and terminates at the outer side of the coracoid process. The flap thus marked out is raised; if possible, save the periosteum and tendons, as in the last operation, by making a longitudinal incision on the outer aspect of the capsule and head of humerus, and raising the periosteum and tendons *en masse* by an elevator. In doing this the arm should be brought across the chest. The bone is sawn, the glenoid cavity examined as in the last method, and after this the flap is replaced and retained by sutures, and a drainage tube inserted behind. The **disadvantages** of this method are—(1) The great mutilation of the deltoid muscle, and, consequently, a much less useful arm is left; and (2) the division of the trunk of the posterior circumflex artery, and, in consequence, more severe hæmorrhage than by the other method. Its only **advantage** is that it is more easily performed than by the single longitudinal incision.

In some cases it may be advisable to excise the joint **from behind,** through a vertical incision from the root of the acromion process downwards, but not extending so low as to divide the circumflex nerve and posterior circumflex artery; this method is specially indicated where the tissues behind are involved in the diseased action, but those in the front comparatively sound. The

difficulty is, of course, the small space at the disposal of the Surgeon in making the vertical incision, without dividing the posterior circumflex artery, and perhaps the circumflex nerve as well.

THE ELBOW JOINT.

Excision of this joint may, just as the shoulder, be **required**—1. For *Disease*—chiefly strumous arthritis. 2. For *Injury*—as in compound and comminuted fractures, compound dislocations, and gun-shot injuries. 3. For the *Results of Injury or Disease*—as in osseous ankylosis, whether straight or angular. In most of the other joints excision should not be performed while there is hope of a cure by ankylosis; but in the elbow joint it is different, and every effort must be made to secure a movable articulation. In cases, however, of ankylosis of the elbow at a right angle, the joint is wonderfully useful; I have seen a case (a medical practitioner) where it was almost impossible, without close scrutiny, to tell the difference. To control **hæmorrhage** during the operation, empty the limb of blood by vertical elevation and apply ESMARCH's elastic tourniquet over the upper part of the brachial artery.

Position of the Arm.—An **assistant**, standing on the side opposite the diseased limb, grasps the arm above and below the elbow, keeps it moderately flexed and raised from the body and carried across the patient's chest, so as to thoroughly present the posterior aspect of the joint to the Surgeon. If more convenient this assistant may stand at the shoulder of the same side, instead of on the opposite side. The **patient** should be drawn close to the edge of the table, should be slightly inclined to the sound side, the diseased side being raised by pillows. The **Surgeon** stands on the same side as the joint to be excised, facing the patient. It may be performed by three different forms of incision—(1) The **H**-shaped incision (SYME); (2) another, which is simply the **H**-shaped incision *minus* one of its upright bars; and (3) a single longitudinal vertical incision (LANGENBECK)—(in this case it is the **H** deprived of one of its vertical limbs and also the cross-bar).

I. By the Single Longitudinal Vertical Incision (Fig. 63).—This is the form most frequently adopted. The arm being held in the position just described, begin the incision in the middle

line, two and a half inches above the elbow, and carry it downwards and a little outwards—(*i.e.*, *outwards*, as the arm is now held, or towards the ulnar side)—over the olecranon process and upper part of the ulna, ending two and a half inches below the joint. If preferred, the incision may be made a little nearer the inner side, because of the presence of the ulnar nerve, and especially where it is intended to clear the inner condyle first.

Fig. 63.

EXCISION OF ELBOW

Observe the Ulnar Nerve passing over Internal Condyle.

In cases where there are sinuses on the posterior aspect, cut the skin and cellular tissue so as to join them, even though by so doing the incision is not straight; after this proceed as in ordinary cases. The upper part of the incision is carried firmly *down to the humerus* so as to divide the tendon of the triceps longitudinally; the lower part exposes the subcutaneous ulna. The assistant now extends the elbow joint, while the operator inserts his left thumb into the wound to make the triceps tense, and

peels it and the other structures on the outer side—the common tendon of the extensors and the anconeus muscle—from the outer condyle of the humerus and head of radius. In doing this the edge of the knife must be kept close to the bone and rasping against it. In cases where, in excision for disease, the periosteum is swollen and loosened by inflammation, this separation should be accomplished by means of a periosteum elevator, the periosteum and tendons being raised *en masse*. By this means the outer condyle and the head of the radius are cleared; by clearing the outer side first the tension is lessened and the operator can more easily deal with the structures at the inner side of the joint, among which is the ulnar nerve (SPENCE). Many Surgeons prefer to clear the inner side of the joint first, and for this reason make the incision rather nearer the ulnar side. Mr MAUNDER pointed out that in clearing the outer side it is important to preserve the fascia over the anconeus, which is continuous with the tendon of the triceps and attached to the posterior border of the ulna, so that the power of extension of the elbow joint may be preserved. In like manner, the inner side of the joint must be cleared, first turning off the triceps and then the rest of the soft parts lower down—the common tendon of the flexors and pronator radii teres—till the inner condyle is fully exposed. In doing so the periosteum elevator should, if possible, be used, but if not, the edge of the knife must be kept close to the bone and carefully follow all its sinuosities so that the ulnar nerve, which lies between the internal condyle and the olecranon process, may escape injury (Fig. 63). The flaps are now to be held aside with blunt hooks, and then the assistant must again moderately flex the elbow; the olecranon process is then seized with the lion forceps, and the operator snips it off with the bone pliers, after having, if necessary, partially divided it with the saw. The assistant next forcibly and fully flexes the joint till the fore-arm touches the upper arm, and then holds them vertically at right angles to the table, and at the same time he pulls the fore-arm towards the table and pushes the humerus upwards; the Surgeon then, with a touch of the knife, divides the strong lateral ligaments close to their attachment to the condyles of the humerus, as they are narrowest at these points. The condyles of the humerus are then to be cleared and divided by

Butcher's saw; as before, the outer is cleared first and then the inner, keeping in mind the presence of the ulnar nerve. In sawing the humerus, grasp the part to be removed with a lion forceps to steady it, and make the line of section parallel with the lie of the articular surfaces; the section should pass through the upper part of the olecranon and coronoid fossæ and the widest part of the condyles. The assistant then forces the bones of the fore-arm out of the wound, the orbicular ligament is completely divided, and the ends of the bones cleared by the knife or elevator till the articular surfaces are thoroughly exposed; the head of the radius may now be divided by the bone forceps, and the rest of the ulna removed by the saw—or the ulna may be grasped by the lion forceps and both bones sawn together, the section including the greater and lesser sigmoid cavities of the ulna, and being a little below the latter. The order, therefore, of bone division in this excision is—(1) The olecranon process; (2) the lower end of the humerus; (3) the head of the radius; and (4) the rest of the ulna. It is by no means essential to divide the bones in this order: the lateral ligaments being divided, the radius and ulna may be projected back, cleared, and divided without previously dividing the olecranon process, and then the lower part of the humerus cleared and sawn. The position of the ulnar nerve at the inner side must never be let out of mind, although the nerve itself should always be out of sight, especially during clearing of the inner condyle and final division of the ulna; the brachial artery is not in great danger, the brachialis anticus muscle lying between it and the wound. In clearing the bones of the fore-arm it may be necessary to partially separate the insertion of the brachialis anticus into the base of the coronoid process of the ulna, but its insertion should not to any great extent be interfered with; the biceps tendon, inserted into the tubercle of the radius, is not, of course, touched at all. In this operation the following parts are **divided**—(1) The integumentary structures; (2) the separation of the muscles mentioned from the bones; (3) the ligaments of the joint; (4) humerus, radius, and ulna; and (5) the following vessels, which require to be ligatured—(*a*) Branches of the superior profunda, (*b*) branches of the inferior profunda, (*c*) the anastomotic branch, and (*d*) the radial recurrent.

For the purpose of **drainage** a tube must be introduced well into the wound, and its lower end brought out at the lower angle of the incision; in cases where there is a sinus on the inner side of the joint, it should be utilised for drainage, and the whole of the longitudinal incision stitched up closely. In sharp-spooning any sinuses on the inner aspect of the joint, be very cautious lest you scrape through the ulnar nerve, as it might be lying in the softened mass of tissue, and more especially in distortions of the joint, due to disease or injury.

After Treatment.—In excision for **Disease** we must guard against ankylosis. After the operation the wound is encased in a thick wrapping of antiseptic dressing, slightly flexed, and laid on a pillow, no splints being required, except, say, a lead splint to steady it. Sometimes it is found to be more grateful to the patient to place it in the extended position with a *light* weight attached to the wrist, to prevent the bones coming into actual contact. This plan is to be strongly recommended as the best preventive against ankylosis, the weight being just sufficient to steady the parts, and not to separate them too widely; nor must it be used too long lest the opposite extreme be reached, and a "flail-like" joint result. It is kept thus for ten days, and at the end of that time the weight is removed every morning, and the arm flexed as far as the patient can comfortably bear it, and left thus till night, when the weight is again re-applied. By the end of three weeks the hand should be able to touch the patient's nose, back of head, etc. If the weight is not employed, after the first inflammatory symptoms have passed off, and union by the first intention taken place—say, at the end of a week or ten days—passive movement should be commenced, at first merely altering its position from day to day: flexed one day, extended the next, and so on. Later, however, the movements must be more extensive, and pronation and supination added. When the patient leaves his bed, which he should be able to do in a few days, the arm must be carried in a sling midway between pronation and supination, the thumb uppermost, but extended during the night and a light weight applied. The after treatment of excision for **Injury**, however, differs somewhat from the above, because the great danger in this case is the possibility of a useless "flail-like" joint, especially in cases where much bone

has been removed and the periosteum has also been destroyed. An angular splint, with a joint opposite the elbow, will be necessary so as to keep the parts at rest and yet allow sufficient passive flexion and extension. Pronation and supination must also be attended to, but for this purpose the splint will require to be removed.

The amount of bone removed in excision for disease should not be too meagre, lest osseous ankylosis result. The whole condyloid extremity of the humerus should be removed, the saw passing through the olecranon and coronoid fossæ, but at the same time taking care to leave the broadest possible osseous surface; the greater and lesser sigmoid cavities of the ulna should be removed, as well as the head of the radius.

Partial Excision for **Disease** is not good, as it is apt to result in osseous ankylosis, or else in a return of the disease; for **Injury,** it is often unsuccessful and more dangerous to life. In disease there is but little danger of a "flail-like" joint resulting. It is never thought necessary now-a-days to resort to the barbarous proceeding, formerly much in vogue in the early days of joint excision, of moving the joint like a pump-handle several times a-day immediately after the operation. This is an excessively painful proceeding; but, apart altogether from this, the results of this plan of treatment were often very unsatisfactory—in some cases being ankylosis, in others a "flail-like" joint. In addition to using the weight and pulley to steady the parts and keep the muscles from pressing the bony surfaces together, *e.g.*, in excision of the elbow joint, Professor CHIENE sometimes uses a box-like splint of perforated sheet-lead, outside the ordinary dressings, into which the arm is laid, the whole being fastened by a few turns of bandage.

The **advantages** of the single straight incision are—(1) It avoids transverse division of the triceps, and, therefore, the action of this muscle as an extensor is preserved; (2) it further avoids a transverse cicatrix behind the joint, which is apt to interfere with flexion of the joint; (3) recovery is more rapid, provided the wound is well drained; and (4) as there is no transverse cut, passive movement can always be commenced early. A **disadvantage,** sometimes mentioned, is that it is more difficult to drain thoroughly.

RÉSUMÉ of the above operation:—

1. Straight incision made, five inches long, with the joint semi-flexed, the incision being raher nearer the ulnar side at the lower part, but in the middle line above.
2. Structures on the inner side are peeled off the humerus, the joint being at first held extended, but later is to be flexed. *Take care of ulnar nerve.*
3. Do the same on the outer side, taking care to preserve the fascia common to anconeus and triceps intact.
4. Remove the olecranon, flex the arm still more, and divide the strong lateral ligaments by cutting on the condyles of the humerus.
5. Force out the end of humerus, and divide it through its broadest part, and parallel with the articular surface.
6. Clear ends of radius and ulna, and divide them a little below the lesser sigmoid cavity.

Steps 2 and 3 may be reversed, and the bones divided without removing the olecranon, thus:—After dividing the lateral ligaments, clear the anterior aspect of the coronoid process, and make a circular sweep round radius and ulna, and then divide them just below the lesser sigmoid cavity; after this clear the humerus and divide it through the upper part of the olecranon fossa.

II. **In the H or the ⊢ forms** a transverse incision is made from the inner margin of the olecranon to the articulation between the outer condyle of the humerus and the head of the radius; and then another incision three inches long, parallel with the axis of the limb and a little way to the outer side of the ulnar nerve; this is the ⊣-shaped form, and, if we make another longitudinal incision at the outer end of the transverse one, we complete the first form of incision—the H-shaped form. The chief **objections** to these forms of incision are—(1) The transverse division of the triceps, and the transverse scar afterwards interfering with flexion; the division of the muscle itself lessening or destroying its power as an extensor. (2) If the transverse cut fails to heal by the first intention, passive motion cannot be begun at the proper time without interfering with the healing process. Its alleged **advantages** are—(1) The bones are more readily exposed; and (2) it admits of better drainage, through the inner incision.

III. Another method of operating is by **two Lateral Incisions.** The inner should be made first, and is shorter than the outer, which may be made of any convenient length. The external lateral ligament is divided and the head of the radius removed; and then the humerus is to be disarticulated and forced out at the external wound, and divided by a narrow-bladed saw; next, the ulna is cleared, protruded, and sawn. The **advantages** claimed are—(1) Less injury to triceps; (2) it provides better drainage; and (3) the scars are lateral and not posterior.

In the case of **Partial Excision** of the elbow joint, where the lower end of the humerus alone is removed, it is necessary to do it through lateral incisions, as it is impossible to reach the joint from behind, on account of the olecranon process. It may be done through a single long internal lateral incision, but it is usually necessary to use a short external as well, so as to divide the strong external lateral ligament. This is an operation that may be required in ankylosis from injury, and after fractures about the elbow joint in children. The real condition has probably not been recognised at the time of the accident, and by-and-by the joint becomes stiff and useless. In such cases be specially careful of the ulnar nerve, as it will probably be displaced or enveloped in a mass of new bone. The lower end of the humerus is divided into two portions by the bone pliers, and the separated parts are then removed. In this way the insertions of the triceps and the brachialis anticus into the ulna are left intact. Excision of the elbow is a less fatal operation than amputation of the arm. An occasional cause of death is suppurative inflammation of the medullary cavity of the humerus, causing osteo-phlebitis, pyæmia, and death.

THE WRIST.

Complete excision of the wrist includes removal of the ends of the radius and ulna, all the carpal bones, and the bases of the metacarpal bones as well (see Fig. 65). It may be **required for**—(1) *Injury*, just as in other joints, compound and comminuted fracture, compound dislocation, and gun-shot wound; few cases of excision for injury are on record. In the Crimea three cases of wrist injury were excised, with only one death. (2) *Disease*, as scrofulous caries, excited by some slight injury, as a sprain; chronic

rheumatic synovitis, leading to caries and destruction of the joints. Excision shortens the disease, and lessens the risk of long continued suppuration, and so far as the operation is concerned the risks to the patient are almost *nil.*

Principles.—In former times the results of excision were anything but satisfactory, the usual result being either a recurrence of the disease, in cases of partial excision for carious disease; or a stiff and useless hand, from extensive interference with the tendons encircling the joint, and imperfect after treatment. Of later years, however, it has been shown that complete excision may be performed and yet leave a useful hand, provided that—(1) all the diseased bones and cartilage-covered surfaces of the radius and ulna, and the bases of the metacarpal bones are removed; (2) that all the tendons concerned in the movements of the fingers and thumb are preserved uninjured; (3) that we can obtain firm fibrous ankylosis of the wrist; but even with firm bony ankylosis the result is good, because the movements of flexion and extension at the elbow make up for the loss of movement at the wrist; and (4) that we commence passive movement of *all* the joints of the fingers and thumb very soon after the operation.

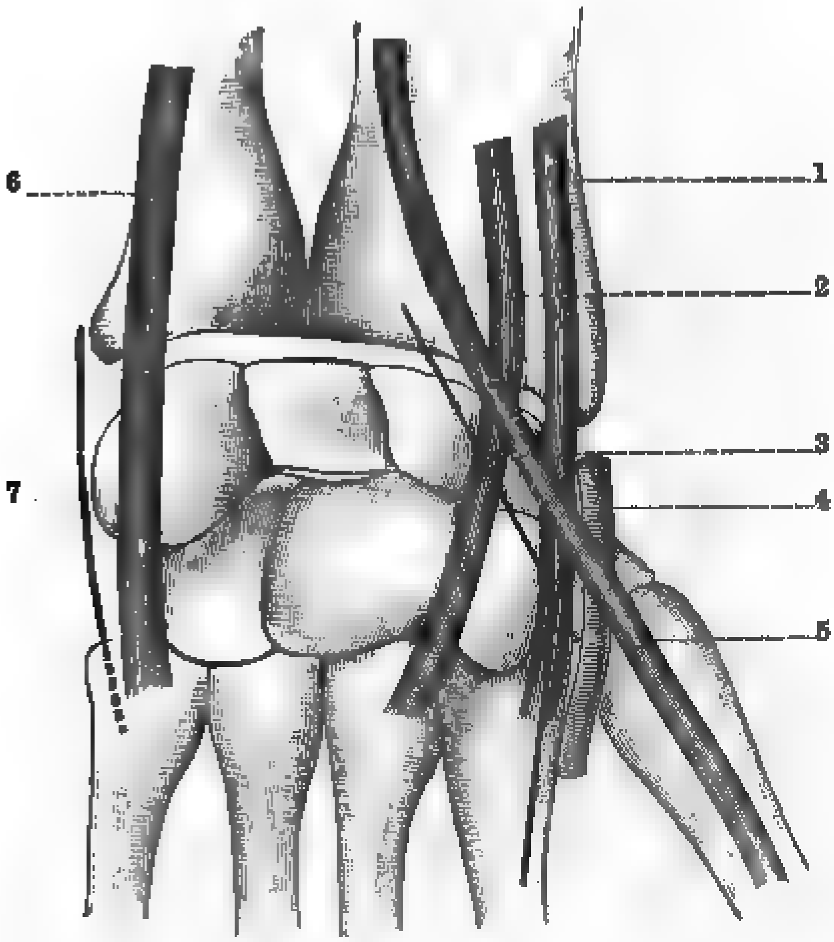
I. **Lister's Method.**—The **guides** for this operation are—1. The tubercle on the middle of the dorsal surface of the radius, immediately to the ulnar side of which lies the tendon of the extensor secundi internodii pollicis. 2. The tendon of the extensor secundi, passing from this tubercle, obliquely to the root of the thumb, crossing the radial artery at a point nearly on a level with the base of the metacarpal bone of the thumb.

To control **hæmorrhage** and prevent oozing during the operation, the limb is first emptied of blood by vertical elevation, and ESMARCH's elastic tourniquet applied about the middle of the fore-arm. Any adhesions must be broken down, before beginning the operation, by forcible free movement of all the joints, when the patient is under chloroform. An **assistant** holds the fore-arm and hand pronated, with the wrist slightly flexed, and the Surgeon makes the **Radial Incision,** starting from the middle of the dorsal aspect of the radius, on a level with the styloid process, and passing downwards and outwards towards the inner side of the *metacarpo-phalangeal* articulation of the thumb; but on reaching

the line of the radial border of the metacarpal bone of the index finger, it is carried downwards longitudinally for half the length of that bone. The first part of this incision should be parallel with, and a little to the ulnar side of, the tendon of the extensor secundi internodii pollicis, which must not be injured; neither

Fig. 64.

LISTER'S EXCISION.



1. Extensor Carpi Radialis Longior.
2. Extensor Carpi Radialis Brevior.
3. The Radial Incision.
4. The Radial Artery.
5. Extensor Secundi Internodii Pollicis.
6. Extensor Carpi Ulnaris.
7. The Ulnar Incision.

should it be carried too far downwards, lest the radial artery be divided or wounded (Fig. 64). By this incision the tendon of the extensor carpi radialis brevior (2) is divided. The soft parts are then to be separated from the bones, with the knife guarded by the thumb nail, on the radial side of the incision, and in so

doing the tendon of the extensor carpi radialis longior (1) is divided close to its insertion, into the base of the second metacarpal bone. The two cut tendons, the undivided extensor secundi, and the radial artery are pushed out of the way, and the trapezium separated from the rest of the carpus by means of the bone forceps, entered from below upwards, cutting in a line parallel with the longitudinal part of the incision, as in this way there is less risk of wounding the radial artery. For the present, the trapezium is left in the wound, as its close relation to the radial artery, and the tendon of the flexor carpi radialis, which lies in the groove on its anterior surface, makes its removal at this stage of the operation a difficult matter. The hand is now to be dorsiflexed, and the soft parts on the ulnar side of the incision dissected up as far as can be conveniently done.

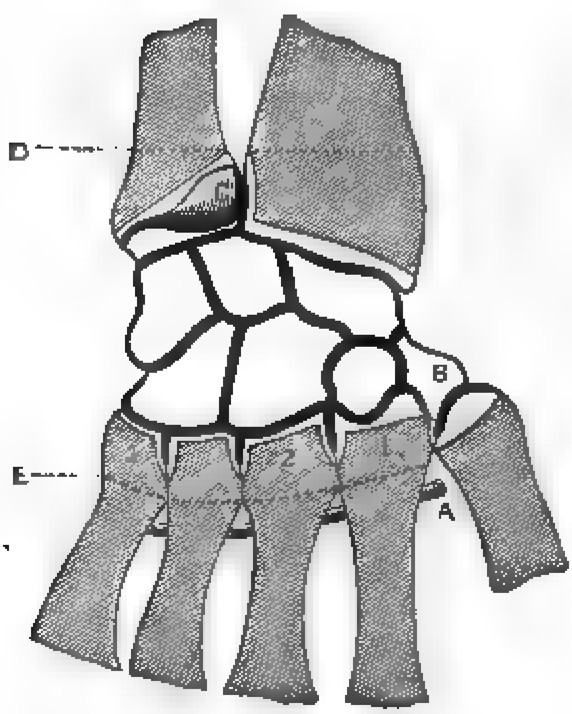
A free **Ulnar Incision** (7) is next to be made, commencing two inches above the lower end of the ulna, and towards its palmar surface, and carried downwards between the flexor carpi ulnaris and the ulna, as far as the middle of the palmar aspect of the fifth metacarpal bone. Through this incision the rest of the tendons on the dorsal surface are raised. During all these manipulations the tendons should be raised as little as possible from their grooves on the dorsal surface of the bones of the fore-arm, or the metacarpus; this is more easily managed if the joint be kept fully dorsiflexed. The tendon of the extensor carpi ulnaris (6) is next cut as near its insertion as possible, and then the dorsal and lateral ligaments of the joint divided. In raising the soft parts from the palmar surface, through the ulnar incision, the wrist joint should be fully flexed, and the knife must be carried close to the ulna, so as to avoid wounding the ulnar artery and nerve. The pisiform bone is to be separated from the other bones, but left attached to the tendon of the flexor capri ulnaris; the flexor tendons are now raised from the front, till the knife is arrested by the hook of the unciform, which must then be snipped off with the bone forceps. The separation must not extend lower down than the bases of the metacarpal bones, lest the deep palmar arch be wounded (Fig. 65, A).

The anterior ligament of the wrist is now divided, and the bone forceps applied, so as to separate the carpus from the end of the

radius, and then from the metacarpal bones; the separated bones are then removed by the aid of the lion forceps. The hand is now everted, and the ends of the radius and ulna are projected through the ulnar incision, and, if extensively diseased, should be sawn transversely, wide of the articular surfaces (Fig. 65, D); if only slightly diseased, the articular cartilages are alone removed. The ulna is divided obliquely with a small saw, so as to remove all the cartilage-covered surface, while the base of the styloid process is retained, and in this way the ulna is left but little shortened;

Fig. 65.

LISTER'S EXCISION.



A. Deep Palmar Arch.

B. Trapezium.

C. Articular Surface of the Ulna.

The dotted lines D and E include the amount removed in extensive disease of the wrist; the unshaded parts, the amount to be removed in cases where the disease is confined to the carpus.

Nos. 1, 2, and 3, indicate the metacarpal bones into which the three tendons divided during this operation are inserted, viz.—

(1) The Extensor Carpi Radialis Longior.

(2) The Extensor Carpi Radialis Brevior.

(3) The Extensor Carpi Ulnaris (after LISTER).

a thin slice is then removed from the inferior articular surface of the radius, and the articular facet for the ulna is denuded by the bone forceps applied almost longitudinally, without disturbing the tendons on the dorsal surface (Fig. 65).

Now, protrude the second and the third metacarpal bones from the radial incision, and remove all the cartilage-covered surface with a narrow-bladed saw, but saving as much of the length of the bones as can be safely done; the fourth and fifth are next protruded from the ulnar incision and treated in the same way.

The trapezium is then seized with the lion forceps and carefully dissected out; and, in doing so, take care of the radial artery, which lies on its outer side, and the tendon of the flexor carpi radialis in the groove on its palmar surface; the head of the metacarpal bone of the thumb is then protruded and cut off with the forceps or saw. Lastly, the pisiform bone is examined; if healthy, the cartilaginous surface is removed and the rest of the bone left, but if diseased it should be entirely removed. The hook of the unciform bone is treated in the same way. The tendons, therefore, divided in this operation, are the three extensors of the wrist. If the bases of the metacarpal bones be divided too low down, the tendon of the flexor carpi radialis may be injured, but it usually escapes, while the flexor carpi ulnaris is left attached to the pisiform bone. All the tendons necessarily divided are cut as long as possible, so that they may form new attachments in the most advantageous position. The radial wound is to be closely united with sutures; the ulnar incision is closed at each end, but its middle part is left open for drainage, and into this a drainage tube is inserted.

After Treatment.—The hand is placed on an anterior wooden splint, with an obtuse-angled piece of cork, connected to its palmar surface by means of fused gutta-percha, and a transverse bar of cork on the under surface, so as to project from the inner side of the splint. By this means the hand is kept in a state of semi-flexion, and the wrist slightly extended, and this favours union of the severed extensors in the most favourable position. The thumb rests on the upper grooved surface of the transverse bar of cork. The arm is bandaged to the splint, but the thumb and fingers are left free. The great objects are—(1) To procure firm fibrous ankylosis of the wrist, by keeping it in a fixed position for six or seven weeks; and (2) to secure perfectly movable fingers and thumb. Passive motion of *all* the joints of the fingers and thumb, including the metacarpo-phalangeal articulations, is commenced on the second day, while the wrist and fore-arm are kept undisturbed on the splint. The anterior part of the splint may be gradually removed as the range of passive movement is increased. When the patient leaves his bed the arm must be carried in a sling, mid-way between pronation and supination, and, to prevent the hand

drooping to the ulnar side, two ledges of gutta-percha are fixed to the ulnar side of the splint—one to support the hand, the other to keep the splint in proper position.

RÉSUMÉ of LISTER's operation :—

1. Break down all adhesions by moving *every* joint freely after the patient is under chloroform, and then
2. Make the radial incision, dividing the extensor carpi radialis brevior, but avoiding the extensor secundi internodii pollicis and the radial artery.
3. Separate the parts on the radial side of this incision, dividing the extensor carpi radialis longior.
4. Separate trapezium with first metacarpal bone, taking care of radial artery.
5. Raise the soft parts on the ulnar side of the first incision.
6. Make the ulnar incision.
7. Raise the soft parts still left on the posterior aspect, dividing the tendon of the extensor carpi ulnaris.
8. Next raise the tissues in front, separating the pisiform bone and hook of the unciform.
9. Remove carpus, divide the bones of the fore-arm, and, lastly, remove ends of the metacarpal bones, taking care of the deep palmar arch.

II. The wrist may also be excised by a **single Longitudinal Incision** from the back of the radius to the ulnar side of the tendon of the extensor ossis, obliquely downwards to the middle of the metacarpal bone of the index finger towards its ulnar side (LANGENBECK); or, in the central line of the fore-arm behind, four inches long, commencing one inch and a half above the styloid process of the radius, and ending one inch below the carpo-metacarpal joints (SPENCE).

The same principles are adopted as in the previous method, and it is therefore unnecessary to go over the operation in detail. An evident disadvantage of the single incision is the absence of sufficient provision for drainage; and, therefore, should this method be adopted, it is advisable to make an aperture for this purpose through the palmar surface of the arm, and stitch up the long dorsal incision entirely.

Total excision of the wrist, as above described, is seldom advisable. A rigid anterior splint, with or without elastic extension of the wrist joint, to keep the diseased surfaces at rest and apart, counter irritation, and, if deemed necessary, the hypodermic injection of iodoform or carbolic acid, combined with good food and open-air exercise, may check the disease and preserve a useful, though crippled hand. The arm must be carried in a sling, midway between pronation and supination, and, most important of all, care taken to preserve the movements of the fingers and thumb, while the wrist joint is kept rigid; in short, it should be treated with the same care as that bestowed on the wrist after excision. It may also be necessary to make incisions to let out pus, and remove disintegrated bone, and scrape away the infiltrated tissues.

CHAPTER XX.

SPECIAL EXCISIONS

(Continued).

THE HIP.

THE term "excision of the hip," as ordinarily understood, means removal of the head of the femur only, although the acetabulum may also be removed, if thought necessary. Cases requiring this operation may be classified as usual—1. For *Disease*, advanced strumous disease, accompanied by abscesses, where the patient is in danger of perishing from exhaustion, and the disease has passed beyond the hope of cure by natural means; the usual means, such as complete rest, extension, incisions to evacuate pus and sequestra, scraping, etc., having been patiently tried and failed. In some cases abscesses do not form (the "arthritic" form of the disease), the disease in this case, it is said, having its origin in the synovial membrane, the patient recovering with a useful, though stiffened joint. Just as in the shoulder, the head of the femur is more frequently attacked than the acetabulum, and the upper epiphysis may often be found lying in a state of caries on the dorsum ilii, or in a suppurating cavity with sinuses leading down to it, but the pelvic bones not affected. In these cases excision is indicated to save from a lingering death from "hectic" and widespread waxy disease of the viscera, or from tedious years of suffering, and to secure a more useful limb than nature will, unaided, provide; and the slight operation required for this purpose does not place the patient in any worse position, to say the least of it, than he was in before, and not only so, but removes the cause of the "hectic"—a chronic form of blood poisoning. This condition is usually co-existent with signs of

waxy degeneration, as evidenced by enlargement of the liver and spleen, albumen in the urine, and diarrhœa. Even should there be no sinuses leading down to the joint, if it contain pus, the sooner it is evacuated and the cavity drained, the better—provided it is done antiseptically—for there can be no hope of "absorption" taking place, matters simply going from bad to worse. At the same time all loose pieces of bone should be removed, the diseased surfaces scraped with a sharp spoon, and the limb then put up in the best position for ankylosis, either by the long splint, or weight and pulley; after ankylosis, the increased mobility of the lumbar vertebræ make up for the stiff hip joint. In the, fortunately, less common form where the disease begins in the acetabulum, the natural termination of such cases is death; in them, therefore, the Surgeon is bound to interfere and excise the joint to provide sufficient drainage for the pelvic abscesses and the removal of loose pieces of bone. Excision for disease in *adult* life is almost uniformly fatal, and the operation is therefore confined to childhood and youth. 2. For *Injury*—compound fracture of upper part of femur, and the rare conditions of compound dislocation and gun-shot injuries. 3. For the *Result of Disease or Injury*, the hip joint ought never to be excised for osseous ankylosis in a bad position.

The proper treatment for **Osseous Ankylosis in a bad position** is—(1) To perform subcutaneous section of the neck of the femur, as practised by W. ADAMS; or (2) GANT'S operation of subcutaneous section of the shaft below *both* trochanters, an operation that may be performed in many cases where ADAMS'S operation is impracticable; or (3) SAYRE'S operation of division *above* the lesser trochanter, with concave section of the upper, and convex of the lower part of the divided bone, so as to form a kind of artificial joint. In all cases the limb is then brought down to the straight position. The objections to ADAMS'S plan are—(1) Leaving saw-dust in the deep part of the wound, and (2) the risk of pumping in septic materials during the use of the saw. To get rid of these dangers Professor CHIENE divides the bone with MACEWEN'S knock-knee osteotome.

For the control of **hæmorrhage** during excision of the joint, apply the elastic tourniquet, as in amputation at the hip joint.

It may be excised—(1) by a semi-lunar incision with its concavity directed forwards, commencing midway between the great trochanter and the crest of the ilium, along the posterior aspect of the great trochanter, or (2) by a longitudinal incision, and then a cross one a little above the great trochanter—T-shaped incision. The vertical part of the incision runs somewhat behind the great trochanter, and either has a transverse incision across its upper end, making it T-shaped, or simply a hook-shaped curve, with the concavity upwards, and forwards towards the head of the bone. (3) A simple straight longitudinal incision, four or five inches long, along the *posterior* border of the great trochanter may also be used. The vessels are few at the posterior border, the bone is nearest the surface there, and the incision allows of more easy access to the powerful external rotators. In all cases of excision for disease it will be most convenient to begin with a straight incision, it may be through existing sinuses; the joint can then be examined thoroughly, and, if found too far gone for excision, it can readily be transformed into JORDAN'S amputation.

EXCISION FOR DISEASE.

The patient is placed on the sound side, and then a longitudinal incision is made directly over or somewhat behind the great trochanter, the upper end of the incision being carried forwards over the top of the great trochanter; if more convenient, the T-shaped incision may be used. The limb is carried across the other one somewhat, and the incision is carried down to the bone, the gluteal muscles and the remains of the capsule divided by a probe-pointed bistoury; then the assistant still further adducts the limb and rotates it outwards, and at the same time pushes it upwards till the upper end of the bone is exposed and divided, at a level determined by the extent and situation of the disease—*e.g.*, if the disease has begun in the head of the femur, that bone is sawn below both trochanters; whereas, if it has begun in the acetabulum it may be divided through the neck, leaving the trochanters. Carious cavities must be gouged out of the upper end of the section should any exist, and the acetabulum examined and treated in the same way. It is better to *save the periosteum* if the case admits of such a thing; this is done by a ⊥-shaped

incision, the longitudinal part being over the great trochanter, and the transverse round the bone below the great trochanter; the two halves are then turned aside, with the attached muscles, by a strong periosteum elevator. In this way the periosteum is not stripped off the upper part of the shaft to an indefinite extent, which is otherwise apt to occur.

At the present time Surgeons are coming more and more to the belief that early interference is the proper course to pursue in cases of strumous arthritis of the hip joint; the treatment adopted is a mixture of "Arthrectomy" or "Erasion" and excision —removal of the *head* of the bone, sharp-spooning carious cavities, and removal of every trace of diseased synovial membrane with the scissors, knife, and sharp spoon, carefully clearing out all caseating foci, and afterwards irrigating the wound thoroughly with solution of the bichloride or carbolic lotion, drying and dusting with iodoform, which seems to have a special germicide action on the tubercle bacillus. The disease usually begins in the head of the bone, at the epiphysial line; and the object aimed at is excision of the head with the least possible disturbance of parts; the incision should be as limited as possible, and the bone divided *in situ*—not dislocated first, as in the older operations. The incisions used are principally two in number:—

1. **White and Langenbeck's Method** (Fig. 66).—The patient lies on the sound side, and the diseased limb is semiflexed and adducted and a straight incision made over the head and neck of the bone, in the direction of the fibres of the gluteus maximus (*i.e.*, in a direction from the posterior superior iliac spine to the middle of the great trochanter). The incision begins two inches above the tip of the trochanter, and passes downwards for an inch and a half along the outer aspect of that bone, the whole incision being from three and a half to four inches long. The capsule is opened, the edges of the wound held aside, and the neck of the bone divided with a narrow saw, or better, MACEWEN's osteotome, outside the diseased point; in order to secure freer access, some split the trochanter vertically without disturbing the tendons.

2. **Hueter and Parker's Method** (Fig. 67).—The patient lies on his back with the limb fully extended, and a straight incision is made from a point immediately below the anterior superior spinous

Fig. 66.

EXCISION OF HIP BY POSTERIOR INCISION.

(WHITE and LANGENBECK's Incision.)

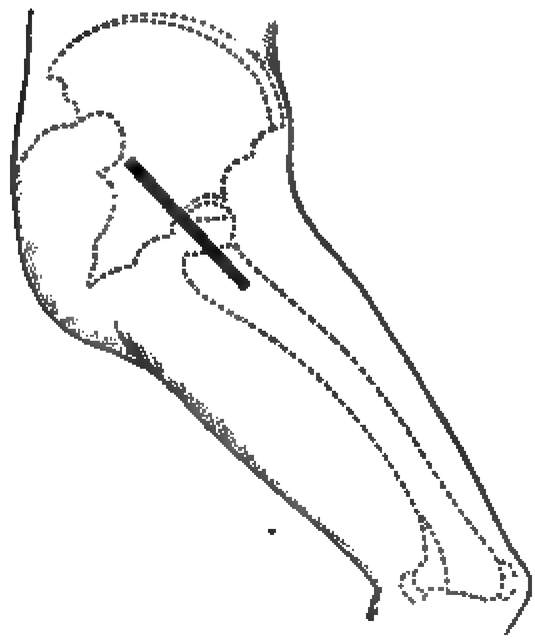
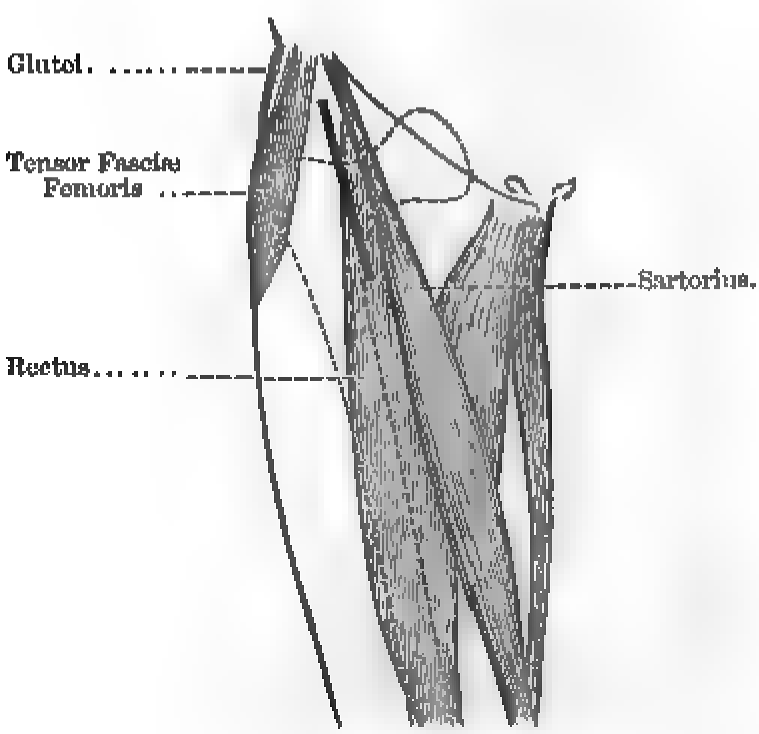


Fig. 67.

EXCISION OF HIP BY ANTERIOR INCISION.

(HUETER and PARKER's Incision.)



process of the ilium downwards and slightly inwards for three or four inches; this incision passes between the tensor fascia femoris and the glutei muscles on the outer side, and the sartorius and rectus on the inner side. The capsule is opened at the upper part of the incision, but the Y-ligament should be left as far as possible undisturbed; the bone is removed as in the last method, the acetabulum and the rest of the joint examined and treated according to circumstances. The patient rests in bed with his leg extended and steadied by a light weight and pulley. The only apparent objection to this method is the absence of free drainage; but if the wound be kept aseptic, little drainage is required, and in any case it is very easy to make a posterior opening for this purpose. The special advantages are—(1) No muscles are divided; (2) no vessels or nerves of any size are divided; and (3) the anterior wound allows of the early application of a double THOMAS's hip splint, so that the patient can be taken out of doors and get the benefit of fresh air almost from the very first (BARKER).

EXCISION FOR INJURY.

Excision for injury, or in the dead subject, is a much more difficult operation. The patient is placed on the sound side, and an assistant holds the thigh, slightly flexed, while the operator is making the first incision. Either the semi-lunar or the simple straight incision may be used; the other incisions described above may also be tried, for the sake of practice. The incision must be carried right down to the bone, so as to clear the posterior aspect of the great trochanter, passing through the skin, superficial fascia, with its vessels and nerves, the deep fascia, and dividing the three glutei muscles, pyriformis, obturator internus and gemelli, obturator externus, quadratus femoris, and part of adductor magnus. The operator may next remove the overhanging upper part of the great trochanter, as this will enable him to divide the capsule and bone much more easily; further, its removal will allow of better drainage of the acetabulum. The assistant now everts the foot, while the Surgeon divides the remaining structures on the outer side of the great trochanter, as well as the muscles attached to its anterior aspect, chiefly the gluteus medius and minimus, and part of the *vastus externus* and crureus; the foot is then inverted, and the

operator divides the posterior part of the capsule of the joint and the cotyloid ligament. The neck of the bone should then be divided *in situ—i.e.*, without dislocation of the joint, with as little disturbance of the parts as possible, the strong anterior part of the capsule being preserved. After division the head must be seized by a lion forceps, and, by means of cutting and twisting, dissected out. In cases where the bone is divided *in situ*, above the great trochanter, it will not be necessary to disturb the structures much towards the anterior aspect of the joint. All bleeding vessels must now be secured; and the vessels most likely to be divided are those in the neighbourhood of the upper part of the great trochanter—viz., branches from the deep division of the gluteal artery; branches of the sciatic artery, and the ascending branches of the external circumflex branch of the profunda; and probably also branches of the obturator, and the internal circumflex branch of the profunda—all of which arteries give nutrient branches to the hip joint.

After Treatment.—An interrupted long splint, with iron brackets opposite the wound, to allow of easy dressing, may be required, to prevent the femur protruding at the wound. The usual treatment, however, is by the weight and pulley, the foot of the bed being raised, and part of the patient's own weight acting as the counter-extending force. When the wound is partly healed THOMAS's hip splint may be applied, and the patient allowed to go about in the open air as much as possible. Bony ankylosis is rare (HOLMES). The shortening is usually pretty considerable, and a high-heeled boot will be required as well as a staff, and probably a crutch.

THE KNEE.

As excision of the knee stands, as it were, on the border-land between amputation and excision, it is necessary that great care be exercised in the selection of cases; in properly selected cases the operation is strikingly successful, but in badly selected cases it is as strikingly unsuccessful. The history of the operation shows a higher death rate than amputation. **Cases requiring** excision may be—1. From *Disease*, as strumous arthritis with destruction of the cartilages and limited disease of the bone.

2. For *Injury*, as lacerated wounds of the joint, compound fracture, compound dislocation, and gun-shot injuries. 3. For *Results of Disease or Injury*, as ankylosis in a faulty or useless position. Speaking generally, in a **proper case** for excision the following conditions are necessary:—(1) The disease should be *limited*, not involving the epiphysial cartilages. (2) The patient should be *constitutionally healthy*; there should be no evidence of such a constitutional affection as the tubercular, nor should there be waxy disease of internal organs. (3) The condition requiring it should be the result of an *accident* and not the expression of constitutional mischief, in which case excision would do no good. (4) It must be in the *chronic* stage. (5) There should be no sinuses leading down to suppurating and septic cavities; if such exist, then the operation of excision should only be used as an exploratory measure, with everything ready for amputation there and then if necessary. What amputation to perform will necessarily depend on the state of the case—the five more likely, in order of trial, are CARDEN or GRITTI at the knee, SPENCE, TEALE, or the "modified circular" at the lower third of the thigh. (6) The patient should not be *too young*, as the epiphysial lines are near, and if injured or removed, the growth of the limb will, to a great extent, be checked; fourteen or fifteen is considered the most favourable age, but it may range from fifteen to thirty years of age. Mr GANT, it is true, has operated successfully on cases at the advanced age of fifty-three, but such examples are rare. Besides, in young children there is a probability of recovery without such a severe operation; rest, incision, scraping, and drainage may work wonders. Further, in children the joint disease is probably only a symptom of profound constitutional cachexia. (7) The patient should not be *too old*, for then the reparative power will be deficient to unite the bony surfaces and fill up the large cavity; beyond thirty, as a rule, it is better to amputate. (8) The patient should be in the prime of life, and free from all visceral disease, and able to bear the long confinement to one position, necessary to procure firm, bony ankylosis.

Arthrectomy or Erasion of the Knee Joint.—When cases of strumous or tubercular arthritis are seen early enough, this operation may not only cure the disease, but even leave a movable joint,

without any shortening of the limb. The **incisions** resemble those used for excision, probably the best being the U-shaped incision using either one or both halves, if possible without division of the ligamentum patellæ; or the ligament may be divided and then sutured at the end of the operation; or again, the tubercle of the tibia may be chipped off with a chisel, leaving the ligament attached to it, and subsequently wired to the tibia. Some again use the straight incision across the front of the joint with transverse division of the patella, the two halves being subsequently wired. When the joint is exposed, the diseased synovial membrane is carefully clipped away or dissected up *en masse;* carious cavities or caseous foci, about the epiphysial lines, are gouged out with a sharp spoon, the part washed thoroughly with sublimate solution dried and dusted with iodoform. The after treatment is the same as for excision.

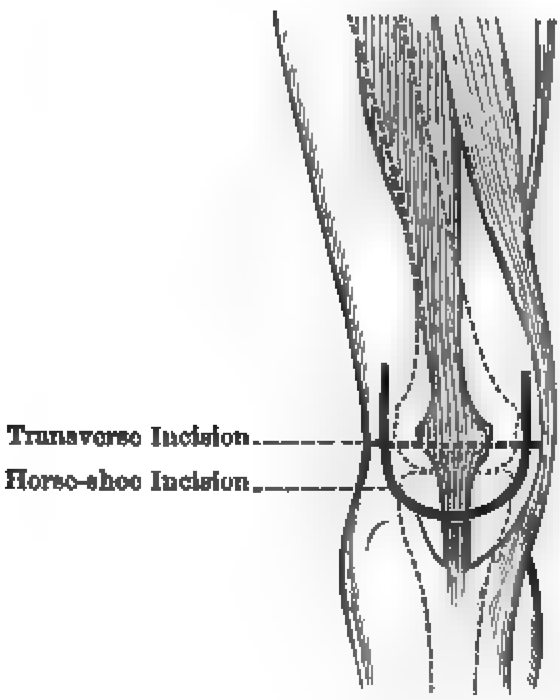
In **excising** the joint four forms of **incision** may be used:— 1. The **H-shaped**—a longitudinal incision, at the outer and inner sides of the joint, united by a transverse one in front, across the patella, or above it as originally practised by VERNEUIL; this incision necessitates an unnecessary amount of division of textures. 2. A single longitudinal incision in the axis of the limb, from three inches above the patella to below the ligamentum patellæ; this form of incision has no advantage here, as in the elbow joint, and besides, it gives no opportunity for proper drainage. 3. A horse-shoe-shaped incision with its convexity downwards, and extending from the posterior margin of one condyle of the femur to the posterior margin of the other, passing below the patella, the lowest part of the curve nearly corresponding to the upper margin of the head of the tibia. 4. A straight incision across the front of the joint from condyle to condyle, the patella being divided transversely; very often this does not give free enough access, and must be supplemented by vertical lateral incisions so as to allow of the soft parts being turned upwards and downwards with more freedom. To check **hæmorrhage,** and render the operation "bloodless," an elastic tourniquet must be applied to the femoral artery.

By the **horse-shoe-shaped incision** (Fig. 68).—This is the best form of incision, as there is not the same objection to cross incisions

in excision of the knee joint, as there is in excision of the elbow joint; the object aimed at in the former (the knee joint) is not a movable articulation, and, consequently, a cross incision is an advantage, as the cicatrix tends to contract and keep the parts tight in front. **Position of the patient.**—He should be in the recumbent position, his knee being slightly bent (probably already so by disease) and is firmly held by an **assistant** seated in front of the patient, or facing the operator, so as to present the knee vertically to the Surgeon, his one hand grasping the thigh and the other hand the leg, while the foot rests firmly on the table. If assistants are

Fig. 68.

EXCISION OF KNEE.



plentiful, two may be employed instead of one—one to hold the leg, and the other the thigh. The **Surgeon**, standing on the right side of the limb to be excised (*e.g.*, if it is the right knee, he stands on the outer side of the limb), makes the horse-shoe incision according to the rules already given; by this incision the integumentary structures, and the ligamentum patellæ are divided, and the patella turned up in the elliptical flap. The inner end of this incision need not be made so far back as to divide the internal saphena vein, but the operator need not have any scruples about

dividing that vessel should it be in his way; besides to carry the horns of the incision well towards the posterior part of the lateral aspect of the condyle will favour drainage afterwards. The knee is now to be forcibly flexed while the Surgeon divides the lateral ligaments, which allows slight separation of the bones, and he next divides the crucial ligaments by cutting *down upon* the head and spine of tibia, so as to avoid any risk of injury to the popliteal vessels. The bones are now held semiflexed, and the femur raised so as to project its condyles, which are then to be cleared for the saw, the bones of the leg being at the same time pulled towards the table. The part to be removed is then grasped with the lion forceps and held by an assistant while the Surgeon himself steadies the thigh, and choosing a *broad-bladed* amputating saw divides the femur through the highest point of the articular surface, and at right angles to the shaft, in the antero-posterior direction, but parallel with the articular surfaces in the transverse—"*parallel to the condyles, and perpendicular to the shaft*" (HEATH), in order to avoid any tendency either to knock-knee or bow-leg. The leg is now forcibly flexed by carrying the foot backwards, so as to project the head of the tibia, which is to be cleared for the saw by means of a blunt-pointed knife, lest the vessels behind be injured. The femur is then steadied by the assistant in charge, while the tibia is drawn in front of it, and supported vertically while the operator holds its upper part firmly with his left hand and removes a thin slice with the broad-bladed saw. The section of the tibia must be parallel with its articular surface, and at right angles to its long axis,—*i.e.*, at right angles to its shaft in both directions. In using the broad-bladed saw, the section of both femur and tibia as the Surgeon now stands, is made from before backwards; but if preferred a BUTCHER'S saw may be used, and the division made from behind forwards, but it is more difficult by this plan to secure a perfectly flat surface; after this the projecting corners of the femoral section are rounded off with the bone pliers, and the diseased pulpy membrane removed with the scissors or sharp spoon.

In cases where the condyles of the femur do not retain their normal shape or obliquity, the guide given by ERICHSEN is the following:—" The patient lying flat on his back, the thigh is flexed

to a right angle, and adducted till the inner side of the knee corresponds to the middle line of the body; the saw is then to be held parallel to the surface of the table." There are two **objections** to sawing the femur through the highest part of the trochlear surface, as is usually recommended—(1) The section will usually be above the broadest part of the condyles, and more especially during the growing period of youth; and (2) in young persons the lower epiphysis will be entirely removed—this epiphysis does not unite with the shaft till attaining twenty years of age. But is it necessary to go so high? It may in some cases, where the disease has spread a considerable distance from the articular surface; but, as a rule, in proper cases the section may be made through the broadest part of the condyles, and any remaining cartilage pared off with the knife or removed from the trochlea by BUTCHER's saw, cutting *round* the bone, or else by the bone forceps. The operation of clearing the bones must be conducted very carefully, keeping the edge of the knife close to the bone, on account of the proximity of the large popliteal artery and its articular branches, especially in cases of pathological distortion. The *Superior Internal Articular* passes round the femur, above the internal condyle and *under* the tendon of the adductor magnus, and the *Superior External Articular* passes round immediately above the outer condyle; the *Inferior Internal* passes below the internal tuberosity of the tibia, between the bone and the internal lateral ligament of the joint, and the *Inferior External* passes above the head of the fibula, but beneath the external lateral ligament and the tendon of the biceps. The *Azygos Articular* enters the joint by piercing the ligament of WINSLOW.

The **Patella**, if much diseased, should be removed; if only slightly, it should be denuded, as in GRITTI's amputation; if healthy, it may be left. As a rule, it ought to be removed, as it is of no use, since it does not keep the bones together; it may further interfere with drainage in the early stages, and disease may break out anew in it afterwards. The **Arteries** likely to be divided in this operation are those taking part in the general anastomoses around, or in the joint, viz.:—The five articular branches of the popliteal already mentioned, together with branches from the anastomotica magna of the femoral, and the recurrent articular

branch of the anterior tibial artery. The flap is then turned down and fixed by sutures, and though no doubt it seems very redundant, it should not, I think, be curtailed. Drainage tubes are to be inserted into the posterior angles of the incision, hence the necessity of beginning and ending the incision towards the *posterior* part of the two condyles, and carried well upwards into the highest limits of the synovial pouches.

The mode of procedure in this operation should vary somewhat according to the disease present. In cases where the bone or the cartilage is principally affected, the semilunar incision should pass at once into the joint and through the ligamentum patella, all the tissues in front of the joint being turned up as a single flap; but in well marked strumous arthritis chiefly affecting the synovial membrane ("pulpy disease" of the synovial membrane) it should only pass through skin, fat, and fascia, and these tissues be turned up as a separate flap from off the thickened synovial membrane and patella, the membrane and patella being dissected out *en masse* afterwards.

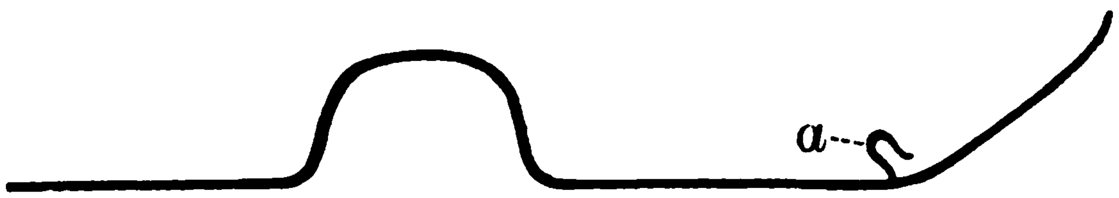
The joint may also be excised by an **incision straight across the front of the joint** from condyle to condyle (see Fig. 68). The patella is then divided transversely, one-half turned up and the other down, the joint excised as in the previous operation. At the conclusion of the operation the two halves of the patella are fixed together by wire or catgut suture. This form of incision does very well in cases where one is *quite certain* that the excision will not have to be transformed into an amputation, either when the patient is still on the operating table, or in the near future; otherwise it should not be adopted, else the amputation will have to be performed at a much higher level, in order to get sufficient flap length, than it would, had the semilunar incision been used in the first instance.

After Treatment.—Various forms of splints are used; they usually consist of a padded back splint, reaching from the fold of the nates to near the heel, and a long interrupted external splint, with a foot piece. But the best method is that devised by Dr P. H. Watson. It consists of two parts:—1. A suspension rod of iron (Fig. 69), extending from the groin to the foot; the upper part is straight, then there is an arch over the joint, a

straight part again for the leg with a hook (*a*) near the ankle joint, for swinging the limb; and, lastly, a raised part running along the dorsum of the foot. 2. Modelled Gooch splint (Fig. 70), long

Fig. 69.

IRON SUSPENSION ROD.



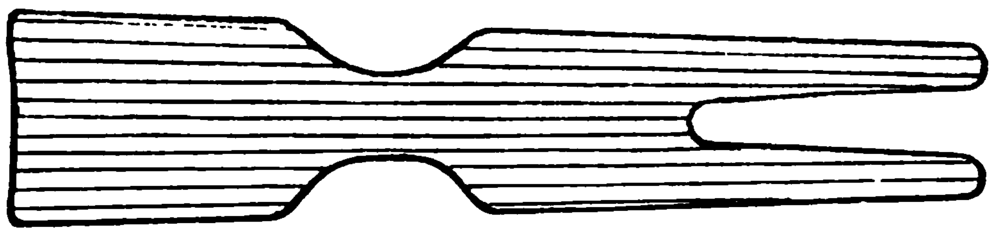
a—Hook for swinging the Limb.

enough to extend from the tuberosity of the ischium to beyond the heel. It is scooped away opposite the joint, and there is an aperture at the lower end, corresponding to the tendo achillis and

Fig. 70.

MODELLED GOOCH SPLINT.

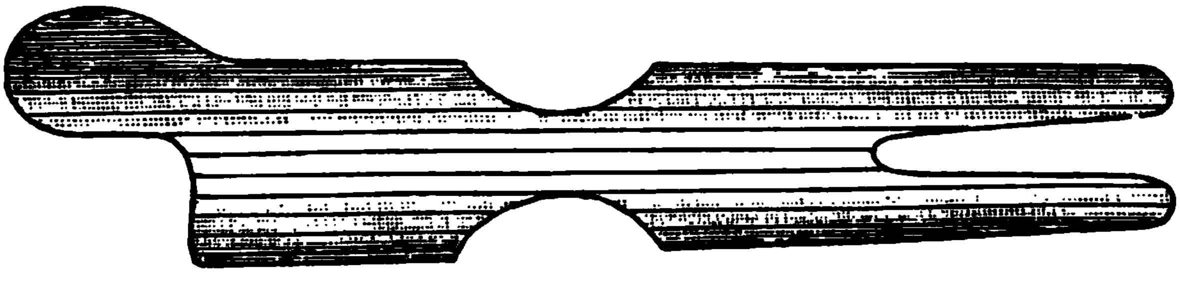
(WATSON.)



heel, like a stirrup, the two sides folding up on each side of the malleoli, while the os calcis is in no risk from pressure. The splint is well padded and covered with gutta-percha tissue opposite the

Fig. 71.

ANOTHER FORM OF WATSON'S SPLINT.



wound, and the leg placed upon it. Next, the iron rod is laid on in front, with folded boracic lint between it and the limb at the groin, upper part of tibia, and ankle. Over all is to be

placed abundance of cotton-wool and then *open wove* roller bandages, applied from the toes upwards, and the whole rendered immovable by plaster of Paris applied above and below the knee. The limb is swung from the pulley of a SALTER'S swing, or from the top bar of an ordinary cage; the foot and leg being slightly, but not too much, raised. By this means the wound can be readily dressed without disturbing the splint or moving the bones; this method, of course, presupposes that the wound will require to be frequently dressed. In cases where it is hoped it will not require to be dressed frequently, a light weight and a well-padded "box" splint, extending from the upper part of the thigh to near the ankle joint, may be used. To maintain the bones in apposition, MORRANT BAKER uses two strong steel pins, which are made to transfix the tibia and bury themselves in the femur, crossing each other like the two parts of a St Andrew's cross; the pins are removed as soon as they become loose. Mr HOWARD MARSH uses ordinary bone knitting-needles instead of steel pins; they are cut short and left permanently in the bone. Others, again, use silver wire or strong catgut sutures. The limb may be kept in this position for an average period of three months (it may be more or less), necessary to procure firm union; for other three months it should be encased in a starch bandage, and gradually brought into use for support and progression. When the bones are completely consolidated, a boot with a high heel will be required, to compensate for any shortening of the limb, usually from one to three inches.

RÉSUMÉ of the foregoing operation:—

1. Make the horse-shoe incision across the front of the joint and turn up the flap.
2. Forcibly flex the joint and divide the lateral ligaments.
3. Separate the bones slightly, and divide the crucial ligaments by cutting down *upon the head of the tibia.*
4. Clear and saw the femur; make cut parallel with the condyles, but at right angles to the shaft antero-posteriorly.
5. Clear and saw the tibia, making the cut at right angles to the shafts in both directions.

If the **transverse incision** be used :—

1. Make the incision across the front of the joint, from condyle to condyle, down to the patella.
2. Saw the patella transversely, then forcibly flex and open the joint.
3. Free and turn up one-half of the patella, and the other half downwards along with the corresponding flap of soft tissues.
4. Divide the ligaments and bones as in the previous operation.
5. Suture the patella with silver wire or catgut.
6. Introduce steel or bone pins into femur and tibia in the form of a St Andrew's cross, as looked at from the front, or a couple of silver wire sutures.

THE ANKLE.

This is an operation but rarely performed; many Surgeons are strongly opposed to it, believing that amputation at the ankle joint is preferable. It may, however, occasionally be performed with advantage; cases appropriate for the operation may be— 1. For *Disease*, provided that the disease is strictly limited to the ends of the tibia and fibula, and the articular surface of the astragalus, and that the operation is performed before constitutional exhaustion has supervened. In cases of tubercular disease of the joint, if at all advanced, excision should be viewed with suspicion. The great risk of constitutional infection must not be forgotten—tubercular disease of the testicle, tubercular infection of the lung, and finally, tubercular meningitis carrying off the patient; whereas, in all probability, had the foot been amputated as soon as the disease was discovered, the life might have been saved; it is the old story, "penny wise, and pound foolish" —saving a *foot* but losing a *life*. 2. For *Injury*, as compound fracture of the malleoli, compound dislocation of the joint, and gun-shot injuries, provided the patient is in the prime of life and unaffected by constitutional disease. In such cases it is often merely a dressing of the ends of the protruded bones, or removal of loose pieces, or disarticulation of the astragalus through the original wound.

There are various forms of **incision** used:—1. **Hancock's**—An incision beginning behind and about two inches above the external malleolus, carrying it forwards beneath that process, then in front of the ankle joint, and terminating about two inches above and behind the inner malleolus. This incision must not penetrate beyond the deep fascia, so that the tendons and their sheaths are uninjured. 2. The best method is by means of **two Lateral Incisions** passing below the two malleoli—one along the inner and posterior margin of the tibia, beginning about two and a half inches above the internal malleolus and passing below it, and then curving forwards round it towards the tendon of the tibialis anticus; the other is of the same extent and form, and is made along the outer margin of the fibula, curving round the external malleolus and forwards towards the tendon of the peroneus tertius. It is better to cut rather *on the posterior edge of the bones*, and then use a periosteum elevator to turn off and raise up the tendons in their sheaths; in this way they are protected from injury. This incision closely resembles BARWELL'S, only he turned forwards at the malleoli at an angle and not in a gently-rounded fashion; it is simply HANCOCK'S without the anterior connection. 3. It is also possible to excise the joint through the **External Incision alone** (BUCHANAN), with, should the disarticulation prove difficult, a short straight incision over the internal malleolus, just sufficient to enable the operator to divide the internal lateral ligament. Whatever method be adopted, there must be no division of tendons, not even those that act primarily on the ankle joint proper; because, though the ankle joint be ankylosed, yet the numerous joints in front of this become more mobile and to a great extent make up for it.

By the Two Lateral Incisions.—The limb is emptied of blood by vertical suspension as usual, and the elastic tourniquet applied a little above the knee. The foot is laid on its inner side, and the **Surgeon**, standing in front of it, makes the external incision *on* the posterior edge of the fibula, according to the rules already laid down; the flap of skin is then dissected upwards, so as to expose the external malleolus and the lower end of the shaft of the fibula. The deep fascia and periosteum are next to be divided *on* the posterior edge of the fibula, and the peronei tendons

(longus and brevis) carefully turned aside in their groove behind the external malleolus by a periosteum elevator, so that the operator can pass his finger behind that bone; the tendons are then held aside with a blunt hook, and the external lateral ligament divided. The external malleolus is then grasped with the lion forceps, while the bone forceps or MACEWEN'S chisel is used to divide the fibula opposite the upper limit of its articular surface —immediately above the broadest part of the malleolus, after which it is to be twisted out. The foot is now turned on its outer side and the inner incision made on the posterior edge of the tibia, the flap dissected up as before, and the deep fascia and periosteum divided on the posterior edge of the tibia; the structures at the inner side of the joint are then to be carefully separated from the bones by a periosteum elevator—tibialis posticus, the long flexor tendons of the toes, and the posterior tibial vessels and nerves, keeping close to the bone for the sake of the vessels. These being held aside, the internal lateral ligament is divided, or the internal malleolus may be treated as the external, being divided with a small saw, or MACEWEN'S chisel, and then twisted out. Next, by a forcible wrench, dislocate the foot outwards, so as to make the astragalus project at the external wound, where its articular surface is removed, or the whole bone excised, according to the extent of the disease or injury. After this the tibia is protruded at the same wound, cleared, and divided. Some Surgeons prefer, the soft parts being held out of the way, to pass a narrow-bladed saw through the wounds, and saw the bones across longitudinally from before backwards, first the tibia and fibula, and then the astragalus; but the bones can be quite easily cut across with the MACEWEN'S osteotome *in situ*, and without the risk of leaving sawdust in the wound, and with less disturbance of parts. Branches of the anterior peroneal artery, and perhaps some of the malleolar twigs, will require ligature; the wound should be drained from the external, or from both incisions.

RÉSUMÉ :—

1. Make the external incision as directed, and separate the structures round it with the periosteum elevator.
2. Remove the external malleolus.

3. Make the internal incision as directed, and separate the structures behind and below it very carefully, for the sake of the vessels there; if a knife be used, keep its edge directed to the bones.
4. Remove the lower end of the tibia with the osteotome, cutting from the inner side.
5. Examine the astragalus, and dress or remove it in whole or part.
6. Clip off or pare away all diseased synovial structure as far as possible.

NOTE.—Division of bones to be effected with MACEWEN'S osteotome, and without previous dislocation of the parts, if possible.

After Treatment.—The method adopted is of little consequence, provided the following conditions are fulfilled:—(1) To keep the foot at *right angles* to the leg; (2) on no account to allow it to become *everted*, a little inversion is of less consequence; and (3) it must be maintained in this position during the period necessary to secure firm fibrous or osseous ankylosis—probably not less than three months—of the ends of the tibia and fibula with the astragalus. For this purpose some means must be adopted to dress the wound without disturbing the splint or moving the bony surfaces, *e.g.*, some method like that adopted by WATSON for knee joint excisions. When the parts are fairly consolidated the leg must be fixed up in some kind of immovable dressing, and gradually brought into use.

THE MICKULICZ-WLADIMIROFF OPERATION.

Osteoplastic Resection of the Foot.—In this operation the ends of the tibia and fibula, the whole of the astrag
os calcis, and the articular surfaces of the scaphoid a
bones are removed. It has been performed in this co
Sir WILLIAM MACCORMAC, in a case where the disease w
in the first instance, to the os calcis and astragalus, on
the adjacent joints secondarily, but where the soft p
the heel were much infiltrated and riddled wi
patient further wished the foot preserved at all c
is placed in the prone position, and *the incis*
the bone at once; the **Surgeon** stands fac

Fig. 72.

Mickulicz's Operation.

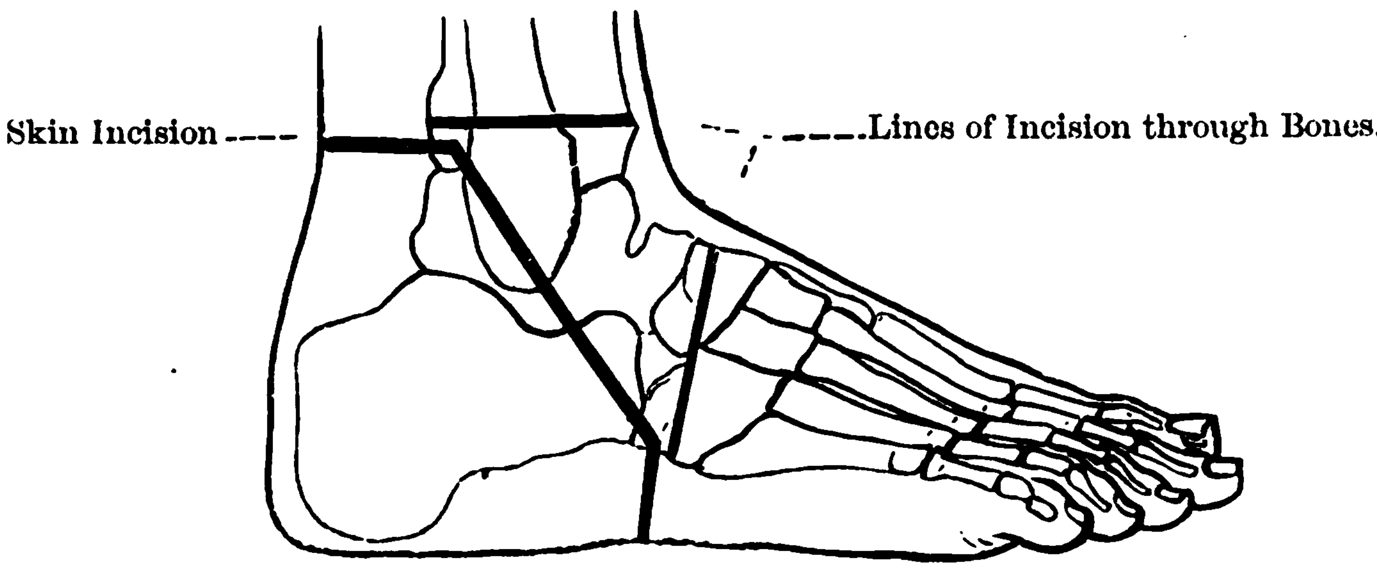


Fig. 73.

Foot after Mickulicz's Operation.

(After MacCormac.)

(1) Make an incision (Fig 72) across the sole of the foot, from a point a little in front of the tubercle of the scaphoid to a point just behind the tuberosity of the fifth metatarsal bone; if it be the right foot the knife is introduced on the inner border, on the left foot it begins on the outer border. (2) From the extremities of this incision make two other incisions to the base of each malleolus; and (3) unite the ends of these by a transverse cut across the back of the ankle. (4) The foot is next flexed, the lateral ligaments divided, and the ankle joint opened from behind and disarticulation completed. (5) The foot is still further flexed, the soft parts are carefully separated from the front, and disarticulation performed at the medio-tarsal articulations, as in CHOPART'S amputation, and in this way the astragalus, the os calcis, and the soft parts covering them are removed. (6) Saw off the articular ends of the tibia and fibula, with the malleoli, and the corresponding surfaces of the cuboid and scaphoid, leaving the anterior part of the foot attached to the leg by a loose bridge of soft parts. (7) Next, bring the foot into a straight line with the leg, and suture the cut surfaces of the bone together with wire or kangaroo tendon. (8) Fix in plaster of Paris splints, bringing the toes into a position of complete dorsiflexion. The result is an artificial *talipes equinus.* The limb afterwards is about a couple of inches longer than its fellow; the toes and metatarsal bones are preserved, and the toes are mobile. The patient walks on the ends of the metatarsal bones, like the digitigrade group of the carnivora (lions, tigers, cats, etc.) (Fig. 73), the foot being fitted with a special boot, and a specially thick sole provided for the boot of the sound foot; the patient, therefore, will be about two inches taller after this operation.

CHAPTER XXI.

DISLOCATIONS.

Before describing the dislocations of the upper extremity in detail, let me say a few words about

THE ANATOMY OF A JOINT.

From the Surgeon's point of view, and for the purposes of Pathology, a joint may be regarded as consisting of three essential parts—(1) The synovial membrane, (2) the articular or encrusting cartilage, and (3) the bone. Some joints also, as the knee, possess inter-articular fibro-cartilages, and round about all joints we have ligaments and soft tissues, but these structures are usually only affected secondarily.

1. **The Synovial Membrane.**—This structure resembles to a great extent, in structure and relations, a serous membrane; its communication with lymphatics, however, does not seem to be so intimate as the latter structure, so that effusions into its cavity are not so readily absorbed again as in the case, for example, of the peritoneum. It lines the inner surface of the ligamentous structures surrounding the joint, and is reflected from them on to the articular ends of the bones, but stops short at the edge of the articular encrusting cartilage, at least in the adult; in the newly-born child it probably covers the encrusting cartilage as well. I ought to mention, however, that Mr Bryant holds that even in the adult it covers the encrusting cartilage, a view also left on record by the late Professor Spence. In the case of joints containing inter-articular fibro-cartilages, we find that both sides of such cartilages are covered by a complete layer of synovial membrane; and further, in joints containing inter-articular ligaments we find the synovial

membrane prolonged and reflected upon them in the form of a tube, so that they are allowed to traverse the cavity of the joint without actually entering it—for, being *outside* the synovial membrane they are also outside the joint, since this membrane is the division between the inside and the outside of any joint. The intimate relation that the membrane bears to the fibrous structures round the joint is important from a pathological point of view, for diseases of the membrane are very apt speedily to involve the fibrous structures, as, for example, in the case of rheumatic and strumous inflammations; in the former it is apt to lead on to cicatricial contraction and fibrous adhesions, outside as well as inside the joint, causing false external and false internal ankylosis. In the latter *(strumous arthritis)*, while the swelling has at first the shape of the synovial cavity, yet very soon the ligaments of the joint become gelatinised and soft, and readily yield, and then the joint assumes a peculiar and characteristic globular appearance, with lateral movement of the articular ends of the bones; this *globular shape* is the shape naturally assumed by fluid and semi-solid bodies when left free from the action of gravity, or from resisting forces, such as strong ligaments and fasciæ, as we see in the case of simple cysts, and in rapidly growing soft malignant tumours. In strumous arthritis, further, the pulpy membrane appears to creep in from all quarters over the articular cartilage, like ivy over an old wall, softening and pitting it by its granulation-like prolongations, and leading to its complete disorganisation.

2. **The Articular Cartilage.**—This structure encrusts the articular ends of the bones, and is of the hyaline variety; the zone of cartilage, however, next the bone is infiltrated with lime salts, or calcified, and here and there a cartilage cell may be observed becoming transformed into a bone corpuscle. The cells, too, are peculiar in their arrangement: near the articular surface they are flattened transversely, a little lower down they are in irregular groups, and still lower they form vertical rows. The cells are the active agents in the production and repair of the cartilage, and they are also the active agents in its destruction; the cells, in disease, instead of forming new capsules as they divide, expend all their energy in multiplication, so that soon we find masses of cells lying in cavities in the cartilage without any capsule round them.

After this neighbouring spaces coalesce and open on the free surface, and in this way the matrix is split up into bands or fibres, and very soon the ends of the bones are bared.

Cartilage, in health, is non-vascular, and therefore depends for its nutrient supply on the blood-vessels of the adjacent bone, and the synovial membrane at its edges; in joints containing inter-articular ligaments, as the hip, the cartilage will, no doubt, receive nourishment from the blood-vessels passing along the ligament, and from the tube of synovial membrane surrounding it. The cartilage is sufficiently porous to allow lymph to percolate through it, and in this way it receives its nutrient supply. So far as I am aware, nerves have not been found in cartilage, and it is therefore devoid of sensibility. The intense pain experienced when a loose body is caught between the articular surfaces is probably due to the stretching of the ligaments; and the pain in "ulceration of cartilage" is due to pressure on the exposed sensitive bone forming the floor of the ulcer. In diseased conditions, however, blood-vessels may be seen shooting up into the cartilaginous matrix. The cartilage does not rest immediately upon the cancellous tissue, but upon a thin crust of compact tissue, the so-called "articular bone." This layer is destitute of Haversian canals, and is therefore non-vascular; further, its lacunæ are very large and have no canaliculi. It is thus whiter in colour, and less porous than ordinary bone, and it is, in all probability, the destruction of this layer that gives rise to the intense "starting pains" following destruction of the cartilage of incrustation.

From its intermediate position, and from its own peculiar vital relations, diseases of the cartilage are usually secondary to disease of the bone or synovial membrane; by some it is stated that the disease known as *Chronic Rheumatic Arthritis*, in the great majority of cases, begins in the cartilages. Disease may also be induced primarily by a traumatism, as a contusion of the joint, frequently seen in the case of the hip, whereby its vital connections with the underlying bone are destroyed and a central ulcer is formed.

3. **The Bone.**—The articular ends of the bones consist of spongy or cancellous tissue, with a layer of articular bone immediately under the cartilage, as already explained. The cancellous tissue combines the greatest strength and elasticity with lightness, and

forms a very important arrangement for diminishing the effects of shock. The articular ends of bones have a different blood supply from the rest of the bone, being supplied by the articular arteries.

The diseases of the articular end of the bone are generally of an inflammatory nature, the chief being *tubercular ostitis;* this condition, unless relieved by an external incision, is very apt to make its way to the surface, attack the cartilage, and open into the joint, and lead to complete disorganisation of the articulation.

NOTE ON DIAGNOSIS OF JOINT DISEASES.

1. The great feature of synovial disease is **swelling**, and the causes usually either *simple synovitis* or *tubercular arthritis;* the former maintains the shape peculiar to the synovial membrane throughout its entire course, and uniform fluctuation can usually be obtained in all directions, but more especially at those points where the membrane is nearest the surface. The latter *(tubercular arthritis)* has at first the shape of the articulation too, but instead of fluctuation it gives a peculiar pulpy or doughy feel; later, the joint assumes the characteristic globular shape, due to softening of the ligaments, with lateral movement of the bones, and "sympathetic abscesses" at various points round it. Synovial disease must be distinguished from disease of the bursæ outside the joint; but in this case some well-known bony point is obscured, as the olecranon process, or the patella, and besides, the swelling has not the *shape* of the articular cavity.

2. The great feature of disease of the cartilage is **pain**; the pain is very intense, and occurs when the muscles are for a moment off guard, as when the patient is dropping off to sleep. He awakes with a sudden start, and the tired muscles again resume duty ("starting pains"); this is repeated again and again, and the patient is gradually worn out. The best treatment for this condition is a heavy weight attached to the limb; opium is sometimes used, but this does not stop the pain, although it makes the patient insensible to it.

3. In bone disease there is neither **marked swelling** nor **very severe pain,** unless the bone be pressed upon. There may be a slight general swelling of the joint with thickening of the affected bone, and the pain is more of a deep-seated aching character, worse

at night or on changes of weather. There is, further, *pain on pressure*, either vertically along the limb or transversely, as in this way the sensitive and inflamed interior is squeezed.

CLASSIFICATION OF JOINTS.

For the study of dislocations, joints may be **classified** into three groups:—(1) Those that depend for their strength mainly upon ligaments, as the sterno-clavicular and the superior radio-ulnar, and the knee; (2) those that are osseously strong, as the hip; and (3) those that are muscularly strong, as the shoulder. Dislocation is *specially* apt to occur in muscularly strong joints, when the muscles are caught unawares, as they are resting. In joints whose strength depends on ligaments we are apt to get a "*sprain*" rather than a dislocation; while in osseously strong joints the articular surfaces are apt to be jammed together, the encrusting cartilages damaged, the result being a *contusion* of the joint.

In all cases of supposed dislocation or fracture of the bones and joints of the extremities, let me remind the student, once for all, that the patient has (in most cases at least) **two arms and two legs**, as the case may be, and that, therefore, the very first thing that he must do is to thoroughly expose and compare the injured with the sound limb. It is possible, however (a possibility which must always be kept in mind), that the sound limb may have received a previous injury, which may render it useless as a standard of comparison. Marked deformity and fixity of a joint point to dislocation; while helplessness, loss of power over the limb, pain, and limpness, point to fracture.

THE UPPER EXTREMITY.

Sterno-Clavicular Articulation.—*Class*, Diarthrosis; *Sub-Class*, Arthrodia, or gliding. The parts entering into its formation are the sternal end of the clavicle, the first piece of the sternum, and the cartilage of the first rib. The articular surface of the clavicle is much larger than that of the sternum, and is invested by a thicker layer of cartilage; the sternal facet is oblique, and looks upwards and outwards. Mr MORRIS points out that this obliquity allows the sternum to advance upon the end of the clavicle during inspiration. There is a complete inter-articular

fibro-cartilage in this joint; it is a flattened, circular disc, but thinner in the centre than at the circumference, and is attached above to the upper and posterior border of the clavicle, and below to the cartilage of the first rib and lower edge of the sternal facet, and, by its circumference, to the ligaments round the joint. In this way there are two complete joints with two synovial membranes. According to Mr HUMPHRY, these two joints have distinct and separate movements—the one between the clavicle and the disc being chiefly concerned in elevation and depression of the shoulder; while that between the sternum and the disc is concerned in the forward and backward movements, the disc moving with the clavicle. It is this part also that is chiefly concerned in the respiratory movements. As the arm hangs by the side, the cavity between the disc and the sternum attains its largest dimensions and is V-shaped; when the arm is raised, it becomes slit-like in form and its cubic capacity lessened, and it is, therefore, this movement that causes most acute pain when the joint is inflamed or otherwise diseased, *e.g.*, in pyæmia. When the joint contains fluid the swelling is best marked on its anterior aspect on account of the thinness of the anterior sterno-clavicular ligament. The most important **Ligaments** of the joint are:—(1) The anterior sterno-clavicular. (2) The posterior sterno-clavicular. (3) The inter-clavicular, passing from clavicle to clavicle across the episternal notch. (4) The costo-clavicular, or rhomboid, which stretches from the cartilage of the first rib to the rhomboid depression on the under surface of the clavicle. It is a very short and strong ligament, and immediately behind it lies the subclavian vein. (5) The inter-articular fibro-cartilage.

Movements.—1. To *raise* the clavicle (as in shrugging the shoulders)—(*a*) the trapezius, (*b*) the levator anguli scapulæ, (*c*) the two rhomboids, and (*d*) the clavicular head of the sterno-mastoid. 2. To *depress* the clavicle—chiefly gravity, and (*a*) the lower fibres of the trapezius, (*b*) the pectoralis minor, and (*c*) the subclavius. 3. *Forward movement* (as in pushing)—(*a*) chiefly the serratus magnus; also (*b*) the pectoralis major, and (*c*) the pectoralis minor. 4. *Backward movement*—(*a*) the rhomboids, and (*b*) the middle fibres of the trapezius. 5. *Circumduction*, a mixture of all the other movements.

DISLOCATIONS OF THE INNER END.

Dislocation of this bone is rare—(1) Because of the very powerful ligaments of the joint and the thick expanded end of the bone, which gives them a very advantageous attachment. (2) The force is usually transmitted along the long axis of the bone, and it is bent, or broken rather than dislocated. (3) The mobility of the scapula. The strength of the joint is entirely due to ligaments, together with the inter-articular fibro-cartilage; it has no muscular or bony strength. In the order of frequency the dislocations are:—

1. **Forwards.**—This is usually *caused* by falls or blows on the point of the shoulder, or by bending the shoulder forcibly backwards. The point of the shoulder is *displaced* downwards, forwards, and inwards; the inner end of the bone passes downwards and inwards, and rests in front of the manubrium sterni, and carries its own head of the sterno-mastoid with it. It is readily reduced by simply pulling the shoulders in directions the reverse of the displacements, *i.e.*, upwards, backwards, and outwards. But, as in all joints the strength of which depends on ligaments, the difficulty is to keep it reduced. It should be **treated** in a way similar to that of fracture of the clavicle through its middle—(1) A pad in the axilla, to overcome the inward displacement; (2) a figure-of-eight round the shoulders to brace them back and so overcome the forward displacement; and (3) a sling to support the elbow to overcome the downward displacement. In addition to these measures, however, something must be provided to keep the end of the bone in its place till the torn ligaments reunite. NÉLATON recommends an ordinary hernia truss, the spring passing under the opposite axilla, and the pad pressing on the joint; this has to be worn for about two months.

2. **Backwards.**—This may be *caused* by the point of the shoulder being driven forcibly upwards, or the hand pulled violently forwards; it may also result from direct violence, such as a kick from a horse. It is, further, sometimes secondary to POTT'S spinal curvature. The *displacements* resemble the last form, the point of the shoulder being carried inwards, and the head of the bone resting behind the sterno-hyoid, and the

sterno-thyroid muscles. In addition, however, to these signs the dislocated end may press on the trachea, œsophagus, or vessels at the root of the neck, producing difficulty in swallowing or breathing, congestion of the veins of the head and neck, and probably coma, from pressure on the great arteries supplying the brain; to relieve these symptoms the end of the bone has been excised. **Treatment.**—A splint well padded, especially opposite the centre of the back, placed transversely behind the shoulders, and to which they are to be braced back by a bandage; in addition to this, should the patient move about, it will be necessary to use an axillary pad and a sling to support the elbow. In all cases of dislocation, the arm must be firmly fastened to the side.

3. **Upwards.**—Very rare. It is *caused* by indirect violence, such as would carry the shoulder downwards and inwards. The end of the bone passes upwards and inwards behind the sternal head of the sterno-mastoid, which has thus an arched outline; the end of the bone lies between the sterno-mastoid and sterno-hyoid muscles in front of the trachea and œsophagus, which are compressed when the patient sits up or leans forwards. The distance between the clavicle and the first rib is increased. The capsular ligament, the sternal attachment of the inter-articular fibro-cartilage and the rhomboid ligament are all ruptured (SMITH). **Treatment.**—Draw the shoulders outwards and upwards and press the head of the bone into place; then put up as in forward dislocation.

DISLOCATIONS OF THE OUTER END.

Acromio-Clavicular Articulation.—*Class,* Diarthrosis; *Sub-class,* Arthrodia. **Ligaments**—(1) The superior acromio-clavicular; (2) inferior acromio-clavicular; (3) coraco-clavicular (conoid and trapezoid). *Conoid,* posterior or internal part; broad above and narrow below, passing from the posterior and inner part of the root of the coracoid process, backwards and upwards to the conoid tubercle of clavicle. *Trapezoid,* anterior or external part; passing backwards and upwards from the hinder half of the coracoid process, to an oblique line extending outwards and forwards from the conoid tubercle. (4) An inter-articular fibro-cartilage, more or less complete, is sometimes present. **Movements.**—At this

joint the movements take place round two axes—upward and downward movements of the arm in an antero-posterior axis, and backward and forward movements round a vertical axis, as in throwing the shoulders backwards and forwards—a kind of universal joint, by which the scapula and humerus are enabled to maintain the most advantageous relations. The strength of the joint is due to ligaments.

Dislocation of the Acromion Process of the Scapula *(formerly known as Dislocation of the Acromial End of the Clavicle).* Dislocation of this joint is more frequent than dislocation of the sternal end of the clavicle. Two forms are described—1. The more common is where the acromion process is forced **underneath the outer end of the clavicle** (*i.e.*, the end of the clavicle passes on to the upper surface of the acromion process; this form is the more common, probably because of the slanting surfaces of the articulation. The *cause* is usually direct violence applied to the scapula, as falls or kicks on the back of the shoulder, not infrequently occurring during the game of football. In complete cases the *diagnosis* is easy; there is pain, loss of power (especially abduction), the shoulder is depressed, and the point an inch or an inch and a half nearer the sternum than on the sound side, but by measurement there is no approximation of the ends of the clavicle. The arm seems lengthened, and there is a distinct projection lying on the acromion process. It is often incomplete from the resistance offered to dislocation by the strong coraco-clavicular ligament. Looked at from the front, the appearances simulate a dislocation of the humerus, there being an apparent elevation with a depression underneath; but from a side view the differences are marked: in dislocation of the shoulder joint the broad arch formed by the acromion and clavicle is seen, but in dislocation of the clavicle we merely see the end of that bone, with the edge of the trapezius standing out in bold relief. **Treatment.**—Raise, draw backwards, and carry the shoulder outwards, and press the end of the clavicle into position; but although easily reduced (as the joint is a ligamentously strong one), it is most difficult to keep in position. This is because the articular facet is very small and slanting, the plane of the joint passing downwards and inwards, so that the bones have [illegible] facility to slip out again.

The method adopted to keep the bones in position will resemble that in dislocation of the inner end of the clavicle. The shoulder is carried upwards, outwards, and backwards, and then a pad of some kind must be placed on the joint to keep the bone in its place—*e. g.*, a PETIT'S tourniquet, the strap of which is passed under the elbow (bent) of the same side, so as to fix the shoulder and press down the bone at the same time, and held in position by a band passing under the opposite axilla. Fortunately, however, even though the bone is not successfully kept in proper position, the utility of the arm is but little affected, only a slight limitation in the upward movements.

2. The acromion may be **forced above the Clavicle.**—This form is very rare. The diagnosis and treatment must be conducted on the same principles as the previous form.

3. A third form is said to occur sometimes where not only the acromion process, but the coracoid as well, is placed above the clavicle.

Dislocation of the Scapula.—The inferior angle sometimes slips from under the latissimus dorsi; this may also take place from paralysis of the serratus magnus muscle, due to injury of the nerve of BELL, or from paralysis of the lower part of the trapezius. When the bone slips from beneath the latissimus it gives a "winged" appearance to the back ("*wing scapula*"). As one of the chief uses of the serratus magnus is for the purpose of pushing, when it is paralysed the patient can push the sound arm more *forcibly and further* than the paralysed one. **Treatment.**—In cases where the angle has slipped from underneath the latissimus a broad belt must be worn to keep the inferior angle close to the chest, otherwise the arm will be much weakened. In paralysis, either of the muscle itself or its nerve, electricity and the endermic or hypodermic application of strychnia, and massage.

THE UPPER END OF HUMERUS.

The Shoulder Joint.—*Class*, Diarthrosis; *Sub-Class*, Enarthrosis (ball and socket). This is the most movable joint in the body, and is more frequently dislocated than any other articulation. Its strength is due to muscles, not ligaments, the bones being kept in apposition by the elasticity of the surrounding muscles

and atmospheric pressure. The "roundness" of the shoulder is caused by the head and tuberosities of the humerus, enveloped by the deltoid muscle; hence, when this muscle is atrophied, or the head of the bone is absent from the glenoid cavity, there is "flattening" of the shoulder; of course, the part of the bone felt through the deltoid is not the *head* proper, but the tuberosities of the humerus. The **Synovial Membrane.**—It is very extensive and lines the margin of the glenoid cavity, and is reflected over the internal surface of the capsular ligament, covers the sides and neck of the humerus, and encloses the tendon of the biceps in a tubular prolongation, in such a way as to preserve the integrity of the membrane and exclude the tendon from the cavity of the joint. It sends (1) a prolongation down the bicipital groove for some distance round the tendon of the biceps; (2) it communicates with a bursa beneath the tendon of the subscapularis; and (3) very often with one beneath the tendon of the infra-spinatus. The large subacromial bursa does not communicate with it. The **Nerves** of the joint are the circumflex, subscapular, and supra-scapular; its **Arteries** are the anterior and posterior circumflex, supra-scapular, dorsalis scapulæ, and subscapular.

Ligaments.—1. The **Capsular,** attached above to the margin of the glenoid cavity beyond the glenoid ligament, and below to the anatomical neck of the humerus, on the upper part, but the lower part is attached a little way *below* the anatomical neck. It is very lax; it is weakest, loosest, and least protected at its inferior part. 2. The **Coraco-Humeral.** This is a strong bundle of fibres at the upper and anterior aspect of the capsule. It passes from the root of the coracoid process, downwards and outwards to the front of the great tuberosity. A few fibres of this ligament project into the joint and are attached to the upper and inner part of the bicipital groove; this fasciculus is known as the "*gleno-humeral*" ligament, and corresponds to the *ligamentum teres* of the hip joint. 3. The **Glenoid Ligament,** a triangular-shaped tire of white fibro-cartilage fixed to the edge of the glenoid cavity; it deepens the cavity and is continuous at its upper part with the tendon of the biceps.

Movements.—1. *Abduction with Elevation*—(*a*) supra-spinatus; and (*b*) middle fibres of deltoid. These only raise the arm to a right angle with the trunk, and the trapezius continues the

movement by elevating the scapula. 2. *Adduction* by (*a*) gravity, (*b*) long head of triceps, (*c*) latissimus dorsi, and (*d*) teres major. 3. *Flexion* (*i.e.*, movement forwards) by (*a*) the anterior fibres of deltoid, (*b*) biceps, and (*c*) coraco-brachialis. 4. *Extension* by (*a*) posterior fibres of deltoid, (*b*) teres major, and (*c*) latissimus dorsi. 5. *Rotation Inwards* by (*a*) the subscapularis, (*b*) pectorals, (*c*) latissimus, and (*d*) the teres major. 6. *Rotation Outwards* by (*a*) the infra-spinatus, and (*b*) the teres minor. 7. *Circumduction.* In addition to the above seven movements, other two are sometimes described, viz.:—*Adduction with Flexion* (as in crossing the arms in front of the chest) by means of (*a*) the pectoralis major, (*b*) biceps, and (*c*) coraco-brachialis. *Adduction with Extension* (as in crossing the hands behind the back) by (*a*) the deltoid, (*b*) the latissimus dorsi, and (*c*) the teres major.

The following peculiarities of this joint deserve special notice:—1. The large head of the humerus and the small glenoid cavity; hence the very free movement. 2. The very loose capsule, and hence the easy pendulum-like motion of the limb in walking. 3. The insertion of muscles into the capsule, they are elastic and prevent the capsule from being pinched between the articular surfaces in the various movements of the joint. *Above*, is the supra-spinatus; *Posteriorly*, the infra-spinatus and the teres minor; in *Front*, the subscapularis; and *Below*, the long head of the triceps. All these muscles are intimately connected with the capsule of the joint, and when they, and the deltoid, are paralysed the head of the bone may be separated some distance from the acromion process. 4. The relation of the biceps tendon: this is to strengthen the joint, and it also gives steadiness and precision in the finer co-ordinated movements of the arm and fore-arm.

When the joint is distended with fluid, as in **Acute Synovitis**, the humerus becomes slightly extended and rotated inwards, and held close to the side, as in this position the cavity can hold most fluid. The joint is evenly rounded, the prominence of the shoulder somewhat increased, and a painful bilobed swelling can be felt in the course of the long tendon of the biceps, in the depression between the pectoralis major and the deltoid. In some cases, too, a soft elastic fluctuating swelling can be felt in the axilla. It (the joint) is firmly fixed by the muscles in the position of greatest

comfort; and movement in *any* direction, but especially that of flexion and extension, as the biceps is thus called into play, will give rise to acute pain. This serves to distinguish this condition from another very common one in this region, viz., injury to, from a wrench or twist of the arm, or disease of, the large subacromial bursa; in this case, flexion and extension do not give rise to any great pain, whereas *active* abduction, by squeezing the bursa, causes acute pain. Further, in inflammation of this bursa we may detect fluctuation at the anterior and posterior borders of the deltoid, and when the *Surgeon* abducts the arm, movement of the shoulder joint is not painful, as the abduction relaxes the deltoid, and thus lessens the pressure on the bursa.

In "dropsy" of the shoulder joint, the arm may be lengthened from the stretching of the long loose capsule; the arm may be pushed up into its proper place but falls down again when the elevating force is withdrawn.

Dislocations.—Dislocation of this joint is chiefly met with in middle and advanced life. The strength of the joint is due to muscles, and it is therefore very liable to dislocation. It *occurs* when the arm is abducted and the muscles caught off their guard, or overpowered, as in falls or blows on the shoulder, elbow, or hand, with the arm outstretched; also if the hand is fixed in this position, and a blow struck on the upper part of the humerus. It is further said to be sometimes due to forcible abduction, or violent contraction of the muscles as in lifting a heavy weight. Whatever the cause may be, the bone always escapes from the capsule at its *lower and anterior part*, as in the position of abduction the head presses on this part, which is the thinnest and least supported portion of the whole capsular ligament. It does not go straight downwards on account of the long head of the triceps, but passes to the front of that muscle. All dislocations, therefore, of the shoulder are primarily subglenoid. The position which the head of the bone ultimately assumes depends on various circumstances—(1) The direction and amount of the force causing the dislocation; (2) the narrow axillary border of the scapula, so that the bone lies on a sort of knife edge and is readily displaced to one or other side; and (3) the relative strength of the muscles on the front and back of the joint, and especially the presence of the long head of the

triceps directing it, in the first instance, forwards; the muscles, too, behind are much stronger than those in front, and therefore the forward dislocations are far more common than the backward.

The different dislocations are named according to the position of the head of the bone, in relation to the different bony points around the joint; they will be given here in the order of frequency. 1. **The Subcoracoid.**—This is generally admitted to be the most common form, although the subglenoid, for reasons already given, runs it very close; indeed, some writers give the subglenoid as the most frequent form. Two forms of subcoracoid are sometimes recognised—(*a*) **Subcoracoid proper,** in which the arm is rotated outwards, and the greater part of the head of the bone is beneath the coracoid process; and (*b*) **intra-coracoid,** where the arm is rotated inwards, so that the greater part of the head is placed internal to a line falling from the tip of the coracoid process. 2. **Subglenoid.** 3. **Sub-clavicular.** 4. **Subspinous.**

In all forms we have—(1) Flattening and squareness of the shoulder; (2) a hollow under the acromion where the head of the bone should be; (3) an apparent projection of the acromion process; (4) the head of the bone is in an abnormal position; (5) rigidity; (6) pain; and (7) an alteration in the axis of the humerus, the elbow being flexed, and the fore-arm supinated. In all dislocations the arm is away from the side: in fractures it is held close to the side, or rather hangs helpless by the side. (8) Another symptom, pointed out by Dr Dugas, is that the patient cannot place the fingers of the injured limb on the sound shoulder, nor allow them to be placed there by the Surgeon, while at the same time the elbow touches the side. The truth of this "pathognomonic tip" I am somewhat inclined to doubt, in reference, at any rate, to subcoracoid occurring in young, loose-jointed persons, with slightly stooping shoulders, and, indeed, in any case of dislocation not seen till some days after the accident. When the hand is on the opposite shoulder the humerus does not lie *transversely* to the chest wall, but very *obliquely;* and there is no reason why, when the spasm of the muscles has passed off, in the form mentioned (the common form), the fingers should not lie on the opposite shoulder, and yet the elbow touch the side. I believe these special "tips" do a

great deal of harm to the student of clinical surgery, and may also lead him into grave errors in practice; the "tips" are only of value to the experienced Surgeon, who does not require such aids. (9) The vertical measurement of the shoulder, from the axilla round the acromion process, is from one to two inches greater on the dislocated side (CALLAWAY). (10) When a straight piece of board is placed with one end resting on the external condyle of the humerus, and the other on the prominence of the shoulder, in a healthy arm the upper end should be separated from the acromion process about an inch, but in dislocation it rests against that process (HAMILTON).

1. **The Subcoracoid.**—This is the most common form. The head of the bone is displaced forwards and slightly downwards, and lies immediately below the coracoid process, resting against the anterior surface of the neck of the scapula, its anatomical neck lying on the anterior lip of the glenoid cavity. **Symptoms**—(*a*) The head of the bone is easily felt in the upper and anterior part of the axilla, and partially or entirely obliterates the sub-clavicular fossa; (*b*) there is slight shortening of the arm and apparent lowering of the anterior fold of the axilla; (*c*) the elbow is tilted outwards, and the axis of the humerus is more oblique than natural; (*d*) the head of the bone may press on the axillary nerves; (*e*) inability to move the arm at the shoulder joint; (*f*) measurement of the vertical circumference of the shoulder increased from one to two inches; and (*g*) it is impossible to pass a finger into the interval between the coracoid process and the head of the humerus. The latissimus dorsi and teres major draw it towards the chest, while the deltoid and pectoralis major draw it upwards towards the clavicle. The sub-scapularis muscle is raised from the neck of the scapula and stretched over the head of the humerus. The posterior muscles are drawn tightly over the glenoid cavity and may be partly ruptured, or the great tuberosity may be torn off; when this is the case, or when the muscles behind are much torn, the humerus will be rotated inwards.

2. **The Subglenoid.**—This is the second most common form (according to some, *the* most common form). This is the only injury about the shoulder joint where the arm is lengthened: in all others it is shortened, or not lengthened to any appreciable extent.

Symptoms—(*a*) The arm is lengthened about one inch, and tilted outwards. (*b*) There is severe pain and numbness in the hand and arm and perhaps pain and œdema from pressure of the head of the bone on the axillary nerves and vessels, and by raising the elbow the head of the bone may be readily seen in its new position. (*c*) The circulation through the upper extremity may be completely arrested, or the artery may be ruptured, and the head of the bone can be felt in the axilla below the glenoid cavity. (*d*) The head of the humerus is one or two finger's breadths below the coracoid process. (*e*) Marked depression of the anterior fold of the axilla. In this case the head of the bone has remained in its primary position—downwards and slightly inwards, resting against the anterior part of the triangular surface of the axillary border of the scapula, just below the glenoid fossa between the long head of the triceps and the subscapularis muscles. It is most frequently *caused* by falls on the hand or elbow. The subscapularis muscle is stretched and partly torn; the supra-spinatus is ruptured and probably also the infra-spinatus. The deltoid muscle is much stretched, hence the great flattening of the shoulder and extreme abduction of the arm.

3. **The Sub-Clavicular.**—This is simply an increased degree of subcoracoid, and probably due to the greater amount of force brought to bear on the limb. The head of the bone lies on the second and third ribs, under the pectorals, below the middle of the clavicle internal to the coracoid process, and the symptoms resemble those of the former dislocation. There may also be œdema and coldness of the limb from the interrupted circulation in the axillary vessels. The muscles and other structures round the joint are much lacerated.

4. **The Subspinous.**—In ordinary cases of this very rare dislocation, the bone rests on the posterior surface of the neck of the scapula, the anatomical neck lying on the posterior edge of the glenoid fossa beneath the acromion. It may, however, be displaced much further back and lie beneath the spine of the scapula. The axis of the limb is directed forwards and outwards, and the elbow is raised from the side and carried forwards; the head of the bone can both be felt and seen in its new position. The subscapularis muscle is torn, and most of the other muscles round the joint are

rendered tense, especially the pectoralis major; both the teres major and the latissimus dorsi are relaxed. This form is *caused* by violence when the arm is stretched across the chest. The circumflex nerve is often bruised or torn; and this may induce secondary degenerative changes resulting in the complete and permanent paralysis of the muscle.

Mr HOLMES describes a **supra-coracoid** dislocation, where the head of the bone forms a distinct projection on the top of the shoulder; it is necessarily always associated with fracture of the acromion or coracoid processes, and is *caused* by some violence forcing the humerus upwards.

The **long head of the biceps** is sometimes displaced from its groove, giving rise to swelling, pain, and fixity of the joint; the arm is locked in the abducted position, and to relieve this condition the shoulder joint must be flexed and the humerus rotated outwards or inwards as the case may be.

In **diagnosing** dislocations of the shoulder, the great point to attend to is the relation of the head of the bone to the acromion and coracoid processes. The **coracoid process** lies in the groove between the pectoralis major and the deltoid, usually a little overlapped by the inner edge of the latter muscle, and about one inch below the clavicle, and the same distance from its outer end, or opposite the deepest part of the anterior concavity at the outer end of the clavicle. It is about one finger's-breadth to the inner side of the head of the humerus. Passing between the process and the clavicle is the strong coraco-clavicular (conoid and trapezoid) ligament. It is necessary to distinguish dislocation from (*a*) fracture of the anatomical neck of the scapula, and (*b*) atrophy of the deltoid muscle. 1. In **Fracture** there will be a history of severe direct violence, the displacement is easily reduced but as readily returns when the support is withdrawn. Both injuries may occur together. Further, the arm will be held close to the side, and there will be marked limpness and mobility of the arm. 2. In **Atrophy of the Deltoid** there will be apparent flattening, but the globular head will still be felt in its proper relation to the coracoid and acromion processes, and the joint is freely movable. The deltoid may be atrophied from *disuse* in cases of ankylosis of the shoulder joint, but is more frequent

from the *loss of trophic influence;* this may be brought about in three ways—(1) In cord lesions causing destruction of the large cells in the anterior horn of the cord at the *origin* of the nerve, as sometimes seen in *infantile paralysis (polio-myelitis anterior acuta);* (2) injury to the *trunk* of the nerve from a blow, or in fracture of the upper end of the humerus; and (3) in disease of the joint, giving rise to a peripheral ascending neuritis, destroying the nerve and paralysing the muscle.

Methods of Reduction.—(1) Direct extension and counter extension, *e.g.*, by pulleys. (2) The unbooted heel in the axilla; this is the usual and best method. The heel is pressed against the axillary border of the scapula to steady and fix it, while the upper part of the foot acts as a fulcrum at the upper end of the humerus; the heel should be pressed outwards away from the chest, so as to avoid injury to the ribs. It matters but little the exact direction in which the force is applied, as the mobile scapula readily places itself in the most favourable position. The traction should be applied directly to the lower end of the humerus, otherwise, on account of the angle formed by the bones of the forearm with the humerus, some of the force is necessarily dissipated, besides straining the ligaments of the elbow joint. If more force is required than can be got by a manual grip, then a worsted laque or large handkerchief should be applied above the elbow, in the form of a clove hitch, and extension made by pulling the ends of the laque. Before applying the clove hitch a turn or two of wetted bandage should be placed round the limb, to avoid slipping, and also to prevent excoriation of the skin. (3) By the knee in the axilla. The Surgeon stands behind the patient, with his foot on the edge of the chair on which the patient is seated, and tries to catch him and the muscles of his shoulder unawares, during the course of the ordinary examination, and thus jerk the bone suddenly into its place. (4) By drawing the arm vertically upwards, parallel with the side of the patient's head, and at the same time fixing the acromion with his foot or other hand. (5) By manipulation. The difficulty in applying this method successfully to the shoulder joint, is the mobility of the scapula. In the subcoracoid form, the movements are:—flex the elbow to a right angle, then flex the shoulder joint, carry the arm across the chest,

rotate inwards till a distinct sense of resistance is felt, then fix the head of the bone, and gradually bring the arm to the side; if this is unsuccessful it may be necessary to try the same movements, but with rotation of the humerus outwards instead of inwards. Unless the attempt at reduction is made immediately after the dislocation, when the muscles are semi-paralysed from shock, the patient should be placed under the influence of chloroform. After reduction of the dislocation, the usual directions are—that the arm should be firmly fixed for at least two weeks, put up in a sling for another fortnight, and at the end of a month passive motion employed. This amount of rest is unnecessary and decidedly injurious; it is simply playing into the hands of "bone-setters." The shoulder is a muscularly strong joint, and there is no tendency, after reduction, to a redislocation. All that is required is to keep the limb at rest for a few days, till the first inflammatory symptoms have passed off, and after that the sooner it is brought into use the better, especially in young persons; at first it is merely to be allowed to swing about easily in a sling, and then passive and active movements begun; or, if in season, give the young patient a spade and pail, and send him to some sea-bathing town. More harm will result from keeping it too long at rest, than from beginning to move it too soon; a good deal may be safely left to the feelings of the patient.

In reducing **old standing dislocations** the probable condition of the axillary artery must be carefully investigated—*e.g.*, whether it is affected with atheroma or calcification, and, whether it may not be included in the new fibrous formations around the joint; because, under these circumstances, it is very apt to be ruptured during the necessary manipulations.

THE ELBOW.

The Elbow Joint.—*Class*, Diarthrosis; *Sub-Class*, Ginglymus. The *bones* entering into its formation are the trochlear surface of the humerus, articulating with the greater sigmoid cavity of the ulna; the lesser head, or capitellum, with which the cup-shaped upper end of the head of the radius articulates. The **Synovial Membrane** is extensive; it covers the margins of the articular

surface of the humerus, lines the coronoid and olecranon fossæ, lines the inner surface of the various parts of the capsular ligament and extends for some distance up the humerus, beneath the tendon of the triceps, and lastly lines the lesser sigmoid cavity and inner surface of the orbicular ligament, and covers the head and neck of the radius. The **Arteries** are derived from the various vessels that anastomose around the joint; its **Nerves** are derived from the ulnar and musculo-cutaneous. The **Ligaments** are—1. The *Anterior*, very thin, passing from the humerus above the coronoid fossa to the anterior surface of the coronoid process, and orbicular ligament. 2. The *Posterior*, also very thin, passing from the humerus above the olecranon fossa to the upper surface and anterior edge of the olecranon process. 3. *Internal Lateral*, consisting of two parts—(*a*) *anterior part*, from the front of the internal condyle of the humerus to the inner margin of the coronoid process; and (*b*) *posterior part*, from the lower and back part of the internal condyle to the inner margin of the olecranon process, and a fibrous band spanning the groove between the olecranon and coronoid processes. 4. *External Lateral*, from the external condyle of the humerus to blend below with the orbicular ligament. The lateral ligaments are very powerful.

Movements.—1. *Flexion*—By (*a*) biceps; (*b*) brachialis anticus; (*c*) supinator longus (this muscle is chiefly a *flexor*, but does not act till flexion has been begun by the other muscles); (*d*) pronator radii teres (after pronation is completed, or when it is prevented by other muscles), and indirectly by the flexors of the wrist and fingers. 2. *Extension*—By (*a*) triceps and anconeus; (*b*) supinator brevis, and indirectly by the extensors of the wrist and fingers. The movements of the joint are limited by ligaments, not by locking of the bones.

THE RADIO-ULNAR ARTICULATIONS.

I. **The Superior Radio-Ulnar**, which is a lateral ginglymus, and may be regarded as a part of the elbow joint, has one ligament, the *orbicular* or *annular*.

II. **The Middle Radio-Ulnar** has two ligaments—(1) The oblique or round ligament, which passes downwards and outwards,

from the tubercle of the ulna, at the base of the coronoid process, to the radius a little below the bicipital tuberosity; and (2) the interosseous membrane which passes obliquely downwards and inwards from the interosseous ridge of the radius to that of the ulna; a little above its lower end there is an aperture through which the anterior interosseous vessels pass to the back of the fore-arm to anastomose with the posterior. Between its upper border and the oblique ligament the posterior interosseous vessels pass to the back of the arm.

III. **The Inferior Radio-Ulnar.**—This, like the superior, is a lateral ginglymus. Its **Ligaments** are—(1) The anterior radio-ulnar, (2) the posterior radio-ulnar, (3) the triangular inter-articular fibro-cartilage, on which the head of the ulna rests; its base is attached to the radius, and its apex to the depression at the base of the styloid process of the ulna.

The **Synovial Membrane** of this joint is called the membrana sacciformis.

The **Movements** of the joint are limited to rotation of the radius round the head of the ulna—rotation forwards is called *pronation*, and rotation backwards supination; the latter is much more powerful than the former, hence mechanics' tools, such as gimlets, etc., are so made that they are introduced by movements of supination chiefly. Another familiar example, and one more generally appreciated, is the cork-screw. The muscles of *pronation* are the pronator radii teres and the pronator quadratus; those of *supination*, the supinator radii brevis, the biceps flexor cubiti, and the supinator radii longus.

Professor HEIBERG and Mr CATHCART have shown that the ulna also moves in pronation and supination; in both cases it is a circumduction, each bone describing a cone, but that of the ulna is the smaller, this bone also moving in the opposite direction to the radius. Mr CATHCART believes that this movement takes place slightly at the elbow joint, but principally at the shoulder, by a rotation of the humerus; in supination the elbow is brought to the side, but in pronation it is carried away from the side—adducted in the one case, abducted in the other. It should be noticed that the fibres of the interosseous membrane are so arranged that much of the force transmitted along the length of the radius is passed on

to and borne by the ulna; this is well seen in cases of dislocation of both bones backwards from a fall on the palm. The radius, from its relation to the hand, receives the shock in the first instance, but part of this is passed on to the ulna through the interosseous membrane, and hence both bones are driven backwards; this is no doubt assisted by the very strong connection between the upper end of the radius and the ulna.

Acute Synovitis of the Elbow.—When the joint is *distended with fluid*, the swelling first shows itself in the hollows at the sides of the olecranon process, especially on the outer side, filling them up and rising up under the tendon of the triceps, and surrounding the head of the radius; so that instead of having two hollows and a prominence between, as in the normal condition, we find two lateral swellings separated by a depression which corresponds to the tendon of the triceps and the olecranon process. The joint is held semi-flexed, at about an angle of one hundred and twenty degrees, and the fore-arm semi-pronated, as in this position the joint is able to contain most fluid, from a general relaxation of all the ligaments. Enlargement of the bursa over the olecranon process is to be distinguished from the swelling caused by synovitis, by the fact that the swelling is over the middle line of the joint, obscuring the olecranon both to sight and touch, and not at the sides of that process, as in synovitis. This form of bursitis is often known as "**Student's Elbow,**" from the supposition that students, in the pursuit after book-knowledge, like St Anthony, rest their elbows upon the table or desk, and place their hands over their ears so as rigidly to exclude all external sounds. It is more appropriately termed "**Miner's Elbow.**" The strength of this joint is mainly due to bones; but this bony strength varies with the position of the joint. In *Extension*, for example, the coronoid process loses its grasp to a great extent, and it is easy to produce dislocation backwards in this position; but the olecranon process in the same position is advantageously placed and powerfully opposes forward displacements. On the other hand, in *Flexion*, the olecranon process loses its antero-posterior grasp, and it is easy to produce forward displacements; but in this position the coronoid process is most firmly locked and opposes backward dislocation. To put it shortly—in full *Flexion* the olecranon process be

feeble hold, but the coronoid process a firm hold; in full ***Extension*** the coronoid has a feeble grip, but the olecranon process has a firm hold. The joint is very strong *transversely*, from the great breadth of the bones and their locking with one another; also, it has very powerful lateral ligaments, and is supported besides by large muscular masses. In health, there is absolutely no lateral movement; so that, if on examining the joint we discover lateral movement, it must either be dislocated or disorganised. But the antero-posterior breadth of the joint is small, and the anterior and posterior ligaments very weak, and it has but little support from muscles, and, therefore, antero-posterior dislocations are more common than lateral. It is also important to notice that the movements of the humerus and ulna take place through an oblique plane, as the axis of the arm and fore-arm do not correspond. In extension the hand passes a little outwards with the bones of the fore-arm; whereas, in flexion it tends to approach the middle line of the body, so as to enable it to convey very various articles easily and gracefully to the mouth.

Injuries of all kinds about the elbow joint (including dislocations) possess a peculiar interest to the practical Surgeon, as they often occur in young children, and are apt to be overlooked till it is too late to remedy the injury, and the child must go through life with a crippled arm, which with some care might have been avoided. Dislocations are specially accidents of childhood and youth; more than one-half the dislocations at the elbow occur in boys between the ages of five and fifteen. In fifty-six cases, twenty-two occurred under the age of fourteen years. It is very often associated with fracture of the condyles, olecranon, or coronoid process.

In reference to the diagnosis of dislocation special attention must be paid to the natural relations (1) of the olecranon process to the prominent internal condyle of the humerus, and (2) the head of the radius to the external condyle. 1. In health, the **Olecranon Process** lies nearer the internal than the external condyle, and when the elbow is extended it lies almost on a level with the condyles. When the joint is flexed to a right angle, the point of the olecranon is vertically below the level of the condyles, so that the three processes in this position form a kind of triangle with the *apex* at the olecranon process. In extreme flexion, the olecranon

is in front of the condyles. Further, the natural distance between the olecranon process and the internal condyle is only just sufficient to lodge the ulnar nerve. 2. The **Head of the Radius** lies immediately below the external condyle, and may be felt rotating during the movements of pronation and supination.

The more important **Structures surrounding** the joint are:—In *Front*—(1) The skin, superficial fascia, and cutaneous nerves; (2) the superficial veins; (3) the deep fascia and bicipital fascia; (4) the tendon of the biceps; (5) brachialis anticus; (6) brachial artery; (7) median nerve; and (8) the radial and ulnar recurrents. *Behind*—(1) The superficial structures; (2) triceps; and (3) the anconeus. On the *inner* side—(1) The muscles arising from the internal condyle (the flexors and pronators); (2) ulnar nerve; and (3) inferior profunda artery. On the *outer* side—(1) The muscles arising from the external condyle (the extensors and supinators); (2) the musculo-spiral nerve and its divisions; and (3) the superior profunda artery.

Thoughtless mothers, and careless nurses, very frequently lift a child suddenly by one arm, or jerk it suddenly to one side by taking hold of its hand. This is a most objectionable and dangerous thing to do. It may (1) fracture the clavicle; (2) dislocate the shoulder; (3) rupture part of the deltoid; (4) dislocate the head of the radius forwards; or (5) cause green-stick fracture of the bones of the fore-arm.

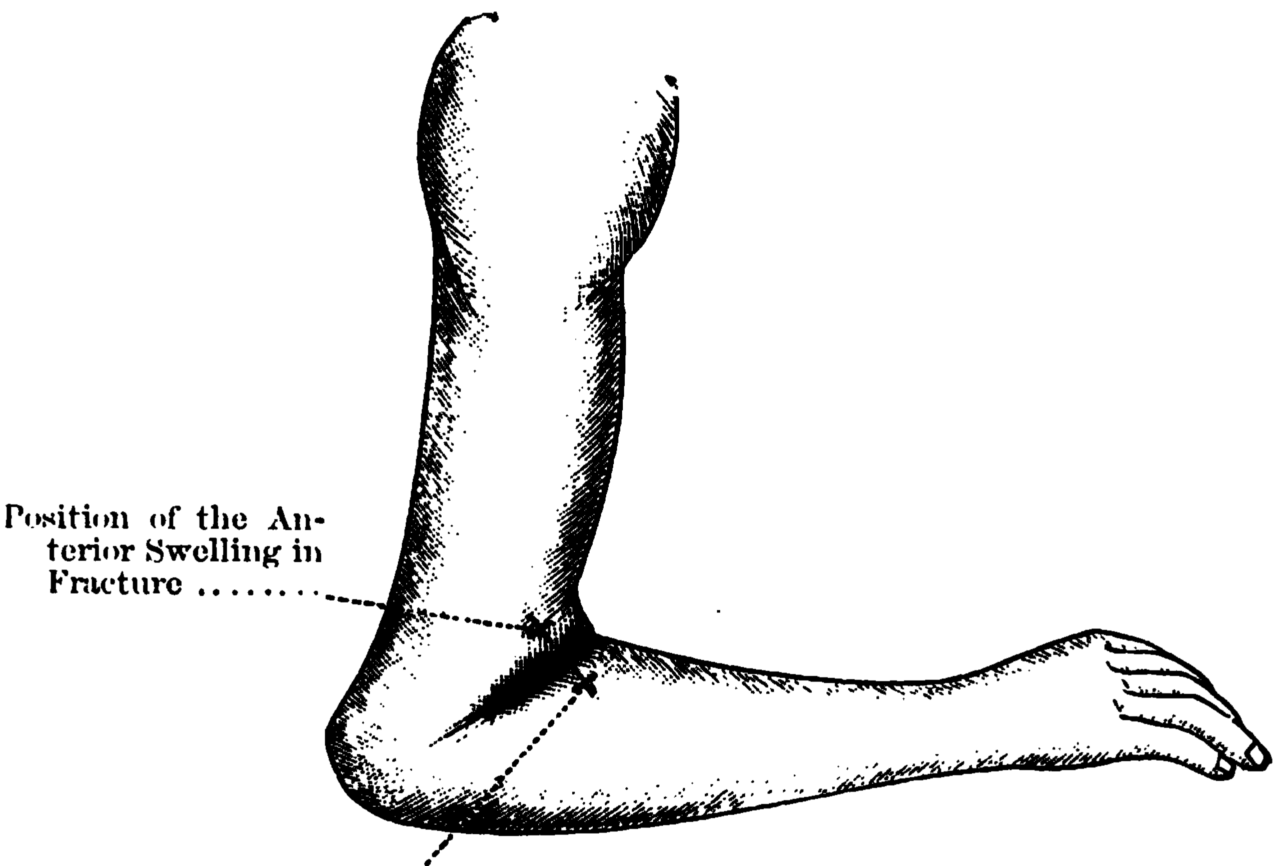
DISLOCATION OF BOTH BONES.

1. **Backwards.**—This is by far the most frequent dislocation in this region; the radius goes with the ulna because of the great strength of the orbicular ligament. It is *caused* by indirect violence, as a fall on the palm of the hand, with the elbow joint extended (or slightly flexed), as in this position the coronoid process loses its grasp of the trochlea, and the bones are driven directly backwards under the lower end of the humerus; part of the shock being transmitted to the ulna through the interosseous membrane, as already explained. This will take place still more readily if the coronoid process be fractured, as sometimes happens. The **Symptoms** are—(*a*) The arm is semiflexed and pronated, and the whole arm

appears shortened; (*b*) there is a projection behind, and a swelling in front, *below* the crease in the skin caused by the flexion of the joint, due to the end of the humerus covered by the brachialis anticus muscle, and the tendon of the biceps (Fig. 74); (*c*) the condyles can be felt in front, and the internal one lies below the olecranon process, and the distance between these bones is greatly increased; (*d*) the arm can neither be fully flexed nor extended; (*e*) there is lateral movement of the joint, but the relation of the head of the radius to the ulna is not altered, being bound to it by the strong

Fig. 74.

DISLOCATION OF BOTH BONES BACKWARDS.



orbicular ligament which is not ruptured; and (*f*) the distance between the condyles of the humerus and the styloid processes at the wrist joint is diminished, but there is no diminution in the distance between the acromion process of the scapula and the condyles of the humerus. If the deformity is easily reduced, and if crepitus be elicited on flexing the reduced bones, and the deformity readily returns when the support is withdrawn, then there is fracture of the coronoid process, as well as dislocation of the bones. It may be possible, by firm pressure in the anti-cubital fossa, to

feel the broken process. The anterior and lateral ligaments of the joint are torn; the tendon of the triceps-aconeus, attached to the olecranon process, is very prominent and tense behind; the biceps and brachialis anticus are stretched over the end of the humerus, forming the anterior projection. The median and ulnar nerves are stretched.

Treatment.—(1) Sir ASTLEY COOPER'S method:—The patient is seated on a chair, and the Surgeon, resting his foot on the edge of the chair, places his knee on the inner side of the joint, while he grasps the wrist and bends the elbow slowly and forcibly; at the same time he presses the upper part of the radius and ulna with his knee, so as to disengage the coronoid process of the ulna from the humerus. (2) Another method is by extension, counter-extension, and co-aptation:—One assistant holds the upper arm, another pulls slowly and steadily at the wrist, while the Surgeon manipulates the bones into position as soon as the coronoid process is unlocked. The arm is then kept in the bent position and carried in a sling, and the ordinary means adopted, if necessary, for reducing inflammatory action. As the strength of the joint (in the antero-posterior direction, at anyrate) is due to the locking of the bones, passive movement must be begun *early*. It may be left quiet for three or four days, till the first inflammatory symptoms subside, and then gentle passive movement must be begun. At the end of two weeks the patient himself may induce active movements of the joint.

2. **Forwards.**—This is a rare dislocation—(1) Because the long and strong olecranon process opposes such a displacement, and it can hardly occur without fracture of that process; and (2) it is *caused* by direct violence, such as a blow or fall on the elbow; and, for this reason again, the usual result is fracture of the olecranon process and not dislocation. The **Symptoms** are—(*a*) Elongation of the fore-arm; (*b*) the marked projection of the condyles of the humerus; and (*c*) the presence of the sigmoid notch in front of the arm, the olecranon process resting against the inferior part of the trochlea. The distance from the condyles of the humerus to the styloid process of the radius and ulna is increased; the tendon of the triceps is very tense.

3. **Lateral Dislocations** are also rare and usually incomplete, and the outward is more common than the inward. The inward

variety may occur when a person is thrown from a trap and alights on the outer aspect of the olecranon. They are rare—(1) Because of the strong lateral ligaments; (2) the locking of the bones; (3) the great muscular masses at each side; and (4) the great transverse breadth of the joint.

ULNA ALONE.

The only dislocation of this bone is backward, and it is very rare. The head of the radius bears its normal relation to the external condyle; the length of the outer side of the arm is unaltered, but the inner side is shortened. The olecranon process is displaced backward, and its distance from the internal condyle much increased.

The **Treatment** is the same as for both bones backward.

RADIUS ALONE.

The usual dislocations of the head of this bone are—(1) Forwards; (2) Backwards; (3) Outwards.

1. **Forwards.**—This is by far the most common of the three, and is, in fact, the second most common dislocation occurring at the elbow joint. It is *caused* by indirect violence, as a fall on the hand in supination, with the elbow joint extended; it may also be caused by direct violence to the bone behind. It occurs very often in *young* persons. The same form of violence applied to the arm of a person in the *prime of life* would probably produce fracture of the lower end of the humerus, dislocation of the shoulder, or fracture of the middle of the clavicle; in an *old* person it ordinarily produces fracture of the lower end of the radius (Colles's); but in *young* persons the usual result is either a dislocation of the head of the radius forwards, or of both bones backwards; not infrequently, however, it is a fracture of the lower end of the humerus, immediately above the condyles. The **Symptoms** are—(*a*) The head of the radius lies in front of the external condyle, and there is a hollow where it ought to be; (*b*) the fore-arm is fixed in a state of semiflexion, and either pronated or midway between pronation and supination, on account of the relaxation of the biceps allowing the pronators to act; (*c*) flexion of the joint is suddenly checked by the head of the radius coming into contact with the lower end

of the humerus—it being impossible to flex the joint beyond an obtuse angle—and this is present whether the dislocation is complete or incomplete; (*d*) any forcible attempts at supination or extension of the arm cause severe pain; and (*e*) the whole fore-arm is twisted, with the outer side somewhat upwards. The orbicular ligament is torn.

The other two dislocations are rare, and may be diagnosed by feeling the head of the radius in its new position, and, as in all dislocations of the radius, the outer side of the fore-arm is shortened, and the movements of the joint restricted. They are often accompanied with fracture of the external condyle into the joint.

Treatment.—Extension and counter-extension by assistants, while the Surgeon presses the head of the bone into position. As the strength of this joint is due to *ligaments*, it is necessary to keep it at rest for a lengthened period to allow the ligaments to re-unite, otherwise the action of the biceps will reproduce the displacement. It should be kept perfectly quiet for four or five weeks. In dislocation forward, the joint must be flexed and a pad applied over the head of the bone, and kept in position by a divergent figure-of-eight bandage, which not only keeps the pad in position, but keeps the elbow joint flexed at the same time. Some Surgeons advise that the arm should be extended and the head of the bone kept in position by a pad and straight anterior splint. If preferred, as in other injuries about the elbow joint, two lateral well-padded angular splints may be used.

The treatment of the other dislocations, not specially mentioned, will readily suggest itself from a study of the two common forms.

THE WRIST.

The Wrist Joint.— *Class*, Diarthrosis; *Sub-Class*, An oblong form of hinge, with two axes of movement—a *long* (as in bending the hand backwards and forwards), and a *short* (as in moving the hand towards the ulnar or radial sides); by some it is called a condyloid articulation. The *bones* entering into its formation are —the under surface of the radius above, and the scaphoid, semilunar, and cuneiform bones below; the ulna is shut out from the joint by the triangular fibro-cartilage.

The **Synovial Membrane** sometimes communicates with the membrane at the end of the ulna (*membrana sacciformis*). The **Arteries** of the joint are the anterior and posterior carpal, anterior and posterior interosseous, and branches from the deep palmar arch; the **Nerves** come from the ulnar and posterior interosseous. The **Ligaments** are four—The anterior, posterior, internal, and external lateral.

Movements. — 1. *Flexors* — (*a*) The palmaris longus, (*b*) the flexor carpi radialis, and (*c*) the flexor carpi ulnaris. 2. *Extensors*—(*a*) The extensor carpi radialis longior, (*b*) extensor carpi radialis brevior, and (*c*) extensor carpi ulnaris. 3. *To bend to ulnar side*—(*a*) The flexor carpi ulnaris, and (*b*) extensor carpi ulnaris. 4. *To bend to radial side*—(*a*) The flexor carpi radialis, (*b*) extensor carpi radialis longior, and (*c*) the extensors of the thumb. **Relations.**—In *Front*—(1) Radial artery, (2) flexor longus pollicis, (3) flexor carpi ulnaris, (4) palmaris longus, (5) tendons of flexor sublimis, (6) tendons of flexor profundus, (7) median nerve, (8) ulnar artery and nerve, and (9) flexor carpi ulnaris. *Behind*—(1) Extensores carpi radialis longior et brevior, (2) extensor secundi internodii pollicis, (3) extensor communis digitorum, (4) extensor indicis, (5) extensor minimi digiti; and (6) extensor carpi ulnaris. On the *outer* side—(1) The extensor ossis metacarpi pollicis, (2) extensor primi internodii pollicis, (3) radial artery, and (4) the radial nerve. On the *inner* side merely the integumentary structures.

The strength of the wrist is mainly due to the numerous strong tendons surrounding it, aided by its own ligaments, the numerous articulations in the neighbourhood, and the presence of the triangular fibro-cartilage. For these reasons dislocation of this joint is very rare, as most of the so-called dislocations of the wrist joint have usually been found to be fractures. The **guide** is to be found in the relation of the base of the metacarpal bone of the thumb to the styloid process of the radius; just as in like injuries about the elbow, the guide is found in the relation of the inner condyle of the humerus to the olecranon process. If the styloid process of the radius and the metacarpal bone of the thumb retain their normal relation, the case cannot be one of dislocation. The styloid process of the radius is more anterior, and passes further down than the styloid process of the ulna. In effusion into the joint,

as in **Acute Synovitis**, the swelling is best seen on the dorsal aspect of the wrist, showing a general fulness, and some bulging between the tendons. The pain is very acute, and, as the joint is so superficial, there will be heat and redness; it is fixed in a slightly-flexed position, and any attempt at movement causes great pain. When, however, the wrist joint is firmly fixed, the fingers may be moved without causing pain; this shows that the inflammation is not in the sheaths of the tendons (*teno-synovitis*). But if, on the other hand, when the wrist joint is fixed, the movements of the fingers give rise to pain, there is strong reason for believing that the synovial lining of the sheaths of the tendons is inflamed. The wrist joint may be dislocated—1. Backwards. 2. Forwards. The usual *cause* is a fall on the palm, or by the hand being bent forcibly backwards.

1. **Backwards.—Symptoms**—This is the most common form and is characterised by (*a*) the presence on the back of the wrist of a prominence with a *convex* upper margin; (*b*) the radius and ulna form a projection on the palmar aspect, but the styloid processes retain their normal relationship; and (*c*) the length of the fore-arm is unaltered, but the distance between the styloid processes and the base of the metacarpus is shortened.

2. **Forwards.—Symptoms**—The whole hand is displaced to the palmar aspect, and there is a prominence on the dorsum with a *concave* lower margin, caused by the radius and ulna, the styloid processes of which can be readily felt.

Treatment.—Draw the hand forcibly downwards, and press the projection into its proper place; it usually slips in with a snap. Then keep the arm in a sling, but be careful that the fingers, thumb, and wrist joint do not stiffen.

Any of the bones composing **the Thumb** may be dislocated, but the most frequent form is **dislocation backwards of the first phalanx** from the metacarpal bone, the base of the first phalanx lying on the dorsal surface of the head of the metacarpal bone. It should be **reduced** either by extending the displaced phalanx, or else by forcibly bending it backwards and pressing the head into position, while the metacarpal bone is flexed as much as possible into the palm to relax the flexor brevis. In many cases, however, great difficulty is experienced in effecting

reduction; the cause of this difficulty is not perfectly understood. Some, following Hey, believe that the difficulty is due to the strong lateral ligaments of the joint, which grasp the head of the bone; but the great majority of Surgeons believe that the tendons of the flexor brevis muscle, with the abductor on the one side and the adductor on the other, together with the sesamoid bones into which they are inserted, is the great obstacle. It is believed that the narrow neck of the metacarpal bone is grasped between the two tendon groups, like a stud between the sides of a botton hole. The **Treatment** will obviously depend on the view the Surgeon takes as to the cause—either subcutaneous section of one or both lateral ligaments of the joint, or one or both tendons of the flexor brevis muscle.

In falls upon the knuckles and dorsum of the metacarpus, besides a possible dislocation of the wrist other three events may happen, viz.:—(*a*) Dislocation of the head of the os magnum backwards; (*b*) Smith's fracture (see "Fractures of Wrist"); or (*c*) sprain of the wrist.

CHAPTER XXII.

DISLOCATIONS OF THE LOWER EXTREMITY.

The Hip Joint.—*Class*, Diarthrosis; *Sub-Class*, Enarthrosis. The **Synovial Membrane** covers the anatomical neck of the femur, lines the inner surface of the capsule, covers the cotyloid ligament, forms a tubular prolongation around the *ligamentum teres*, and covers the mass of fat *(Haversian gland)* lying at the bottom of the acetabulum; it sometimes communicates with the bursa beneath the psoas and iliacus. The **Bones** entering into its formation are the acetabulum and head of the femur. The *acetabulum* is formed by all the three parts of the os innominatum—the ilium forming a little less than two-fifths, the ischium a little more than two-fifths, and the pubic bone the remaining fifth. These three pieces unite, through the Y-shaped epiphysis in the acetabulum, about puberty. The acetabulum consists of a horse-shoe-shaped articular surface, which is deficient opposite the cotyloid notch, and a central non-articular depression continuous with the notch. The strongest and deepest part of the cavity is at its upper and posterior part, the lower and inner part being very shallow and weak. The **Arteries** of the joint come from the obturator, sciatic, internal and external circumflex, and the gluteal arteries; the nerves are derived from the sacral plexus, great sciatic, obturator, and accessory obturator nerves.

Ligaments.—1. The *Cotyloid*, a tire of white fibro-cartilage, attached to the rim of the acetabulum and transverse ligament; it deepens the cavity, closely embracing the head of the femur. 2. The *transverse*, bridges over the notch, converting it into a foramen, and is continuous at each end with the *ligamentum teres;* beneath it the nutrient vessels pass into the joint. 3. The

ligamentum teres, or round ligament, is a Y-shaped structure, passing from the two ends of the cotyloid notch to a depression in the head of the femur. 4. The *Capsular*. The capsular ligament is attached above to the margin of the cotyloid cavity and transverse ligament; and below—in *front*, to the anterior inter-trochanteric line; *above*, to the inner side and upper edge of the great trochanter; *behind* and *below*, to the junction of the middle and outer thirds of the neck of the bone. It consists of circular and longitudinal fibres, and, on the posterior and inferior aspects of the capsule, the fibres are almost all circular, so as not to interfere with the swinging movements of the limb as in walking, and in these situations also the capsule is very thin and very loosely attached. On the anterior aspect of the capsular ligament there is a specially thickened part, known as the *ilio-femoral band*, or Y-shaped ligament of BIGELOW. It is attached above to the anterior inferior iliac spine, and below the two limbs diverge—one to be attached to the upper end of the inter-trochanteric line, the other to the root of the lesser trochanter. The inner slip specially limits extension, and the outer slip, eversion, of the femur. There are also other specially thickened parts of the capsule—(*a*) The *ilio-trochanteric* on the superior aspect, passing from the anterior surface of the root of the great trochanter to the ilium, immediately above the anterior inferior spine. (*b*) The *ischio-capsular* on the under surface, passing from the ischium below the acetabulum to blend with the capsular ligament. (*c*) The *pubo-femoral* ligament, a specially thickened part in front and below. By flexing the thigh upon the trunk and rotating the femur inwards, the Y-ligament is rendered lax; this is of importance in the reduction of dislocations. The centre of gravity falls *behind* the centre of rotation of the hip joint, and the trunk, therefore, naturally tends to fall backwards, but this is prevented by the *ilio-femoral* band. By this wise provision of Nature, muscular effort is not required to maintain the erect attitude, so that energy is economised. There is another part of the capsular ligament that requires special notice, viz., the *cervical reflexion*. This consists of bands of fibres which come off from the inner surface of the capsule, and are reflected upwards on to the neck of the femur, especially towards the anterior and lower, and the posterior

and upper aspects. This reflexion is not necessarily ruptured in intra-capsular fracture, and conveys blood across the fractured point, and by this means will tend to a certain extent to aid the union of the broken parts.

The Movements at the Hip Joint.—**Flexors.**—These muscles flex the thigh on the trunk, or the trunk on the femur. *Direct* flexors (*i.e.*, those that pass from the trunk over one joint only) —(1) The psoas, (2) iliacus, and (3) pectineus. *Indirect* flexors (*i.e.*, muscles passing over two joints, and only acting secondarily on the hip joint—(1) The rectus, and (2) sartorius. **Extensors.**—*Direct*—The three glutei muscles. It should be observed that in the extension movements required at the hip joint in *ordinary* walking the gluteus maximus is not used; it only comes into play when greater energy is required. *Indirect*—The three hamstrings (biceps, semi-tendinosus, and semi-membranosus). **Abductors.**—(1) The gluteus medius, (2) gluteus minimus, (3) tensor fasciæ femoris, and (4) sartorius. **Adductors.**—(1) The three adductors, (2) gracilis, (3) pectineus, (4) quadratus femoris, and (5) obturator externus. **External Rotators.**—(1) Gluteus maximus, (2) gluteus medius (posterior part), (3) pyriformis, (4) obturator internus and the two gemelli, (5) quadratus femoris, (6) obturator externus, and (7) psoas and iliacus. **Internal Rotators.**—(1) Gluteus minimus, (2) gluteus medius (anterior part), and (3) tensor fasciæ femoris. It will be noticed that the external rotators are much more numerous and powerful than the internal, so that the foot naturally tends to fall outwards when one assumes the supine position.

Muscles in direct contact with the Capsule of the Hip Joint.—In *Front*—The psoas and the iliacus. *Above*—(1) The rectus (reflected tendon), and (2) the gluteus minimus. On its *inner* side—(1) The pectineus, and (2) the obturator externus. *Behind* it—(1) The pyriformis, (2) the obturator internus and the two gemelli, (3) part of the gluteus minimus, (4) the obturator externus, and (5) the quadratus femoris.

The **range of motion** of the joint in its various directions is **limited**, in a general way, as follows:—*Extension*, by the anterior fibres of the capsule and ilio-femoral band; *Flexion*, by the contact of the neck of the femur with the acetabulum and soft parts of

the groin; *Abduction*, by the pubo-femoral band and lower part of the capsule; *Adduction*, by the ilio-trochanteric band and the upper part of the capsule in extension, and the ligamentum teres in the flexed position; *External Rotation*, by the inner limb of the Y-shaped ligament during extension, and the outer limb and ligamentum teres during flexion; *Internal Rotation*, by the ischio-femoral and Y-ligament. The ligamentum teres is rendered tense either when the thigh is partly flexed and adducted, or when the limb is flexed and rotated outwards—*i.e.*, flexion with adduction or external rotation. Mr SAVORY also maintains that it is always made tense in the upright position, and is still further tightened in standing on one leg.

In effusion into the joint, as in **Acute Synovitis** (a rather rare condition, pure and simple), the swelling will be difficult to detect, on account of the depth of the joint from the surface, and the thick capsule. As in other joints, it will tend to show itself where the capsule is thinnest—in *front*, internal to the inner head of the Y-shaped ligament, and *behind* at the posterior and lower part of the capsule. In these parts, therefore, any swelling and tenderness must be first looked for; the joint at the same time will be flexed, abducted, and rotated outwards, as in the position of flexion the joint holds most fluid with the least tension, and abduction and eversion relax the outer and inner bands, respectively, of the ilio-femoral ligament.

Bursa under the Psoas Tendon.—Inflammation of this bursa gives rise to symptoms somewhat like those of hip joint disease. It may be possible to feel a fluctuating swelling deep in the groin; the thigh is held in a position of flexion and abduction, the patient is unable to extend it, and should he or the Surgeon attempt to do so there is marked pain, the anterior superior spine follows the movements of the femur, and there is arching forwards of the lumbar spine (*lordosis*) as by this movement the inflamed structure is pressed upon. The joint, however, can be readily *flexed*, and when so held the pain disappears; there is an absence of all rigidity, and there is perfect smoothness of all the movements at the hip joint, as in this position all pressure is removed from the bursa in question. The only movement that cannot be properly performed, therefore, is extension.

DISLOCATIONS OF THE HIP JOINT.

The dislocations of this joint are various, but whatever position the head of the bone ultimately assumes, the primary dislocation, just as in the shoulder joint, is *always* in a downward direction. The forms of regular dislocation in the order of frequency are—(1) Backwards and upwards, upon the dorsum ilii; (2) backwards, into the great sacro-sciatic notch; (3) forwards and downwards, into the foramen ovale; and (4) forwards and upwards, upon the pubes. The first two forms are the most common; in all the four forms the ligamentum teres is usually ruptured, but the ilio-femoral band remains intact.

We have to notice the influence exerted (1) by the Y-ligament; (2) by the tendon of the obturator internus, as it is found in the gluteal region, on the various forms of regular dislocation of this joint:—

1. **The Y-Ligament.**—If this ligament escape rupture, we may get any of the four *regular* forms of dislocation enumerated above; if it be wholly ruptured, the dislocation will be of an *irregular* form. In no case do muscles (except perhaps the obturator internus) exercise any direct influence on the displacement. In dislocation on to the dorsum ilii, and into the great sacro-sciatic notch there is marked *inversion* of the limb; this is because the ilio-femoral band is not ruptured, and the external rotators are powerless to rupture it, and are therefore unable, so long as the ligament remains intact, to evert the limb. For the same reason, in dislocation into the foramen ovale the limb is *flexed.* In dislocation on to the pubes the ligament is lax, and hence the external rotators are at liberty to act, and, having nothing to oppose them, produce marked *eversion.*

2. **The Tendon of the Obturator Internus.**—Bigelow has pointed out that the muscular body of this muscle is usually mixed with tendinous structure; by this means it acquires great strength, and when contracted acts as a powerful accessory ligament on the posterior aspect of the hip joint. It has also been pointed out by the same Surgeon that in dislocations on to the dorsum ilii, and into the great sacro-sciatic notch, the bone passes in exactly the same direction in the first instance; but in dislocation on to the

dorsum ilii, the head, in passing upwards and backwards, passes *between* the tendon of the obturator internus and the pelvis, whereas in dislocation into the great sacro-sciatic notch, the head of the bone as it passes backwards, passes *behind* the tendon of the obturator internus, the tendon lying over the neck of the bone and preventing its ascent.

Mr MORRIS states that when the limb is flexed, abducted, and rotated inwards, the backward dislocations are produced; in *moderate* flexion, the head rests on the dorsum ilii; in *extreme* flexion, it comes to rest near the sciatic notch. When the limb is abducted, extended, and rotated outwards, the dislocation upon the pubes occurs. In very forcible abduction, the head of the bone is sent into the perinæum. If there be neither rotation, forced flexion, nor extension, the head of the bone rests in its primary position —in the thyroid foramen. The dislocations, therefore, it will be observed, all occur in the abducted position of the limb, because (1) during abduction the head of the bone passes to the shallowest and weakest part of the acetabulum, and presses on the least supported part of the capsule; and (2) during abduction the ligamentum teres is loose. The same condition of parts is also brought about, even when the limb is not abducted, if the body be forced over to the dislocated side. The reverse is true in regard to the adducted position. Just as in the shoulder, there is but one primary form of dislocation of the hip joint, and in both cases that dislocation is downwards; in the shoulder the rent in the capsule is at the lower and *anterior* part, but in the hip it is at the lower and *posterior* part. Further, observe that in the shoulder, the forward dislocations are the most common, but in the hip it is the backward forms. The point at which the head of the bone will ultimately come to rest depends on the direction and amount of the violence, as well as on the position of the limb. Dislocations occur chiefly in men during the middle period of life (twenty to fifty), and is specially apt to be produced in certain occupations, as miners and navvies. The same application of violence in an *old* person will produce intra-capsular fracture of the neck of the bone; in *young* persons, fracture of the shaft.

There are **Special Test Lines** made use of in the diagnosis of dislocations of the femur and fractures of the neck of the bone.

1. **Nélaton's Test Line.**—Draw a line from the anterior superior spinous process of the ilium over the outer side of the hip to the most prominent part of the tuberosity of the ischium. In health, the top of the great trochanter should just touch this line in every position of the joint. The disadvantage of this measurement is that the patient has to be rolled over towards the sound side, a movement which may not only be very painful to the patient, but may be actually injurious, as it may loosen an impacted fracture of the neck.

2. **Bryant's Triangle.**—The patient is laid flat on his back, on a firm mattress or couch, and a perpendicular is dropped from the anterior superior spine of the ilium; then a second line at right angles to the first is dropped from it to the top of the great trochanter; then the two lines are joined by a third one from the anterior superior spine to the top of the great trochanter, thus completing the "triangle." The length of the *second* line, compared with a corresponding line on the opposite side, shows the amount of vertical displacement; the length of the *third* line shows roughly the degree of displacement of the trochanter backwards or forwards. The advantage of BRYANT's method is that the measurements can be taken without moving the patient, which is of importance in cases of fracture.

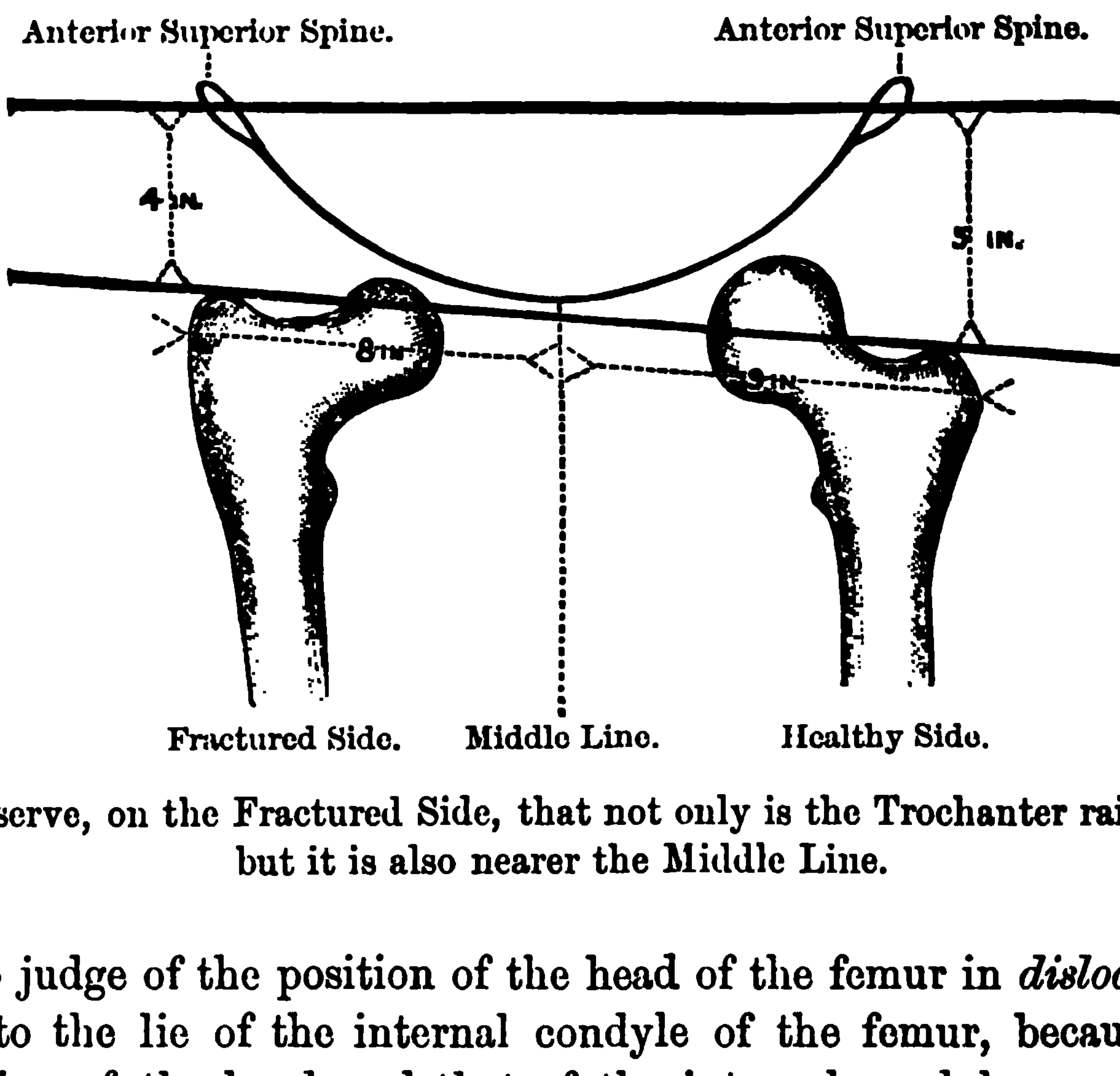
3. **Morris's Bitrochanteric Measurement.**—This is chiefly of use in cases of fracture, and shows the degree of inward displacement of the trochanter, just as BRYANT's method shows the degree of vertical displacement. The distance from the tip of the great trochanter to the symphysis pubis is measured on both sides and the figures compared; on the injured side the distance between the two points is always less. Mr MORRIS has constructed a special measuring rod for this purpose, which shows the state of affairs at a glance.

4. **Another Method,** which I have only seen used by Professor CHIENE, is to mark with ink the anterior superior spines of the two sides, and also the tip of the great trochanter, on each side, and then, by placing two straight pieces of narrow board—or better still, two flexible flat pieces of steel or brass, so as to arch over the prominence of the abdomen—transversely on these four points, and observe whether or not the two rods are parallel with each other.

This method can be used anywhere and by any one, without disturbing the patient in the least. Of course, it only shows the upward displacement of the trochanter, but it could easily be combined with an apparatus like that used by Mr MORRIS, when it would show at a glance not only the amount of the upward displacement, but the amount of the inward displacement as well, and even the extent of eversion or inversion (Fig. 75).

Fig. 75.

FRACTURE OF THE NECK OF THE FEMUR.



Observe, on the Fractured Side, that not only is the Trochanter raised, but it is also nearer the Middle Line.

To judge of the position of the head of the femur in *dislocations* look to the lie of the internal condyle of the femur, because the direction of the head and that of the internal condyle are almost the same (BIGELOW).

Other useful Measurements in injuries of the lower extremity are:—(1) The total length of the limb from the anterior superior iliac spine to the tip of either malleolus. (2) The length of the thigh, from the same point to the upper edge of the patella, or to the adductor tubercle. (3) The length of the leg, from the upper edge of either tibial condyle to the tip of the corresponding malleolus.

THE BACKWARD DISLOCATIONS.

1. **Upon the Dorsum ilii.**—In dislocation on to the *dorsum ilii* (backwards and upwards), which is the most common form, the limb is shortened one or two inches, the knee is inverted, slightly flexed, advanced, and adducted, and rests against the lower third of the opposite *thigh*, and the great toe rests on the upper surface of the tarsus of the opposite foot; the heel is a little raised, and the thigh is flexed, and there is a great bulging at the hip from the projection of the great trochanter, which is directed forwards, and lies nearer the anterior superior iliac spine than natural. There is marked fixedness of the joint, and the head of the bone rests on the ilium, a little above and behind the acetabulum, under the glutei muscles. It is made to lie at this point partly by the force causing the dislocation, but is also pulled up by the glutei, hamstrings, and adductor muscles. Abduction and eversion are impossible, but there is still a slight amount of inversion, adduction, and flexion possible. Another symptom, first noted by SYME, is that if the patient be laid flat on his back on a hard couch or table, the knee of the dislocated side is raised, but the patient's back rests evenly on the table; but if the knee be brought down flat on the table there is a marked lumbar curve produced, just as in hip joint disease. On pressing the fingers into the groin it will be found that the femoral vessels have lost their firm posterior support and seem to lie over a hollow; when compared with the sound side, the sense of lessened resistance is very marked. The short muscles covering the joint behind are much lacerated; the ilio-psoas muscle is very tense, and the pectineus may be torn as well as the glutei. According to BIGELOW, the head of the bone passes between the tendon of the obturator internus and the innominate bone, and finally comes to rest above that tendon (*"backward dislocation above the tendon"*). This dislocation is caused when the limb is in the position already explained (abduction, flexion, and internal rotation), and the patient recei[illegible] result being either a dislocation or [illegible] as in miners; it may also o[illegible] weight and falls down.

2. **Into the Sciatic Notch** *(backwards).*—The **Symptoms** of this form resemble very closely those of the previous dislocation, only they are less marked—it is simply a less advanced form. The limb is shortened about half-an-inch, the knee is inverted and touches the opposite knee, but does not tend to cross over it, and the ball of the great toe rests on the head of the metatarsal bone of the great toe of the opposite foot. There is less flexion and less bulging at the hip than in dislocation on to the dorsum ilii. The head of the bone rests, not in the sciatic notch, as the name would imply, but on the back of the ischium, opposite, or a little above, the level of the spine, and below the tendon of the obturator internus muscle *("backward dislocation below the tendon").* This dislocation is produced when the limb is in the same position as in the last form, but with greater flexion and internal rotation.

The backward dislocations must also be **distinguished** from—(1) *Fracture of the neck with inversion.* In ordinary cases of fracture there is usually marked eversion, which at once distinguishes it from ordinary forms of dislocation. This form of fracture is rare, and the *increased* mobility, the extension of the limb, the marked loss of power, the pain, and the existence of crepitus will aid the diagnosis. (2) *Impacted extra-capsular fracture, with inversion.* Here the limb will probably be extended; BRYANT's line shortened from half to one inch, approximation of the great trochanter to the middle line, as shown by the "bitrochanteric" measurement. There will be great pain over, and probably broadening of, the great trochanter, but the joint will permit movement freely in all directions, though the great trochanter will not move in so large a circle as on the sound side. Further, there will be the usual feeling of resistance in the groin behind the femoral vessels, but on pressing the hand against the outer side of the thigh the ilio-tibial band will be found to be less tense than on the sound side. *Great care is necessary in performing these manipulations, lest an impacted fracture be converted into an unimpacted one.*

Reduction of Backward Dislocations by Manipulation.—The great object is to make the head of the bone pass back to the acetabulum in exactly the same direction as it left that cavity, and, therefore, the limb must be put into the same positions as that in which the dislocation occurred—viz., flexed, abducted, and rotated

outwards. The success of the method depends on the integrity of the ilio-femoral band; it is to act as the fulcrum of the lever, of which the shaft of the femur below it is the long arm, while the part above it is the short arm. The manipulations are—(1) **Flex** the leg on the thigh to relax the hamstrings, and the great sciatic nerve, if need be, and also flex the thigh upon the abdomen, carrying it at the same time into a **position of adduction,** so as to relax the untorn part of the capsule. (2) **Circumduct outwards** (a combination of abduction and external rotation) so as to render the Y-ligament tense, and distend the rent in the capsule; also to make the head pass round the way it came, and turn it through the opening in the capsule. (3) Quickly **extend** and bring the limb to the side of its fellow, so as to make the head pass at once into the deepest part of the acetabulum. When the dislocation is reduced the legs may either be tied together with a pillow between the knees, or the long splint applied. The splint is to be kept on for a week or ten days, and after this the joint should be supported by some fixed apparatus, as a leather splint or a plaster of Paris spica, for two weeks longer.

THE FORWARD DISLOCATIONS.

1. **Into the Foramen Ovale** *(forwards and downwards).*—The head of the bone rests in the thyroid foramen. **Causes.**—Sudden and violent abduction, unaccompanied either by external rotation, or fixed flexion or extension; jumping or falling from a height, with the feet widely apart, as sliding over the end of a loaded waggon or cart; or the sudden movement of a carriage, when one foot is on the step and the other not yet off the ground; and also getting out of bed quickly, when one foot is caught in the bed-clothes, while the other descends suddenly to the floor. The pectineus, gracilis, and adductors longus and brevis are torn, and the psoas, iliacus, glutei, and pyriformis are put on the stretch; the ligamentum teres and capsule are ruptured as before. The obturator nerve is stretched or torn. **Symptoms.**—The limb seems *lengthened,* the toes point downwards and are a little everted, and the foot is separated some distance from the other one—the thigh being flexed and abducted, and in front of the opposite one,

on account of the tension of the ilio-psoas muscle. The hip is flattened, the prominence of the great trochanter absent, and the gluteal fold is lowered; the head of the bone may be felt under the adductor muscles. The apparent lengthening is believed to be due to a tilting of the pelvis over to the injured side; to make quite certain whether it is lengthened or not, the use of BRYANT'S test, or careful measurements must be made from the anterior superior iliac spine to some fixed bony point in the limb, *e.g.*, the tip of the internal malleolus. The movements of adduction and extension are impossible without using great force, and giving rise to severe pain from pressure on the obturator nerve; the limb, however, may still be flexed.

2. **Upon the Pubes** *(forwards and upwards).*—The head of the bone rests on the ilium, rather than the pubic bone, close to its junction with the horizontal ramus of the pubes and on the outer side of the femoral artery. It is **caused** by violence similar to that producing the thyroid variety; but where extension and external rotation of the limb accompany the application of the violence. **Symptoms.**—The limb is shortened and abducted, and there is marked eversion of the foot and knee, and the heel inclines towards the opposite one. The great trochanter lies nearer the middle line than the anterior superior spine. The limb cannot be rotated inwards, but may be slightly flexed. There is sometimes pain and numbness down the thigh from pressure on the anterior crural nerve, and congestion and œdema from pressure on the vessels. This form is said to resemble fracture of the neck of the femur; but it may be distinguished from this by the greater immobility, and by the situation of the head of the bone in the groin.

Reduction of the Anterior Dislocations.—(1) **Flex** the leg upon the thigh and the thigh upon the abdomen, as in the previous dislocations, but, at the same time, **abducting** the limb. (2) **Circumduct inwards** (*i.e.*, adduct and rotate inwards) until the knee is brought nearly to the middle line of the body; these movements relax the rent in the capsule, render the Y-ligament tense, disengage the head of the bone, and bring it round to the opening by which it escaped. (3) **Extend** and rotate outwards, so as to make the head of the bone re-enter the acetabulum.

THE IRREGULAR FORMS.

There are many **irregular** forms of dislocation, and in all some part or the whole of the **Y**-ligament is torn through. The following are a few of the better marked varieties :—

1. **The Everted Dorsal.**—This has all the usual signs of dorsal dislocations, except that there is eversion instead of inversion, and there is but slight adduction and the limb may be extended. It is supposed by some that the outer band of the ilio-femoral ligament is ruptured.

2. **The Supra-Spinous.**—The limb is shortened to the extent of two or three inches, a little abducted and everted, and the head of the femur is felt just below the anterior superior spine of the ilium, above and to the outer side of the ilio-femoral ligament. As in the last form, the outer head of the ilio-femoral ligament is believed to be torn.

3. **The Subspinous.**—The hip is flattened, BRYANT's line is shortened about two inches, there is extreme eversion and the head of the femur is found below the outer part of Poupart's ligament, a little to the inner side of the anterior inferior iliac spine.

4. **In the Perinæum.**—This occurs when the limb is greatly abducted at the moment the violence is applied. There is extreme abduction and marked flexion, and the head of the femur can be felt in the perinæum. The foot may be either inverted or everted.

THE KNEE.

The Knee Joint.—*Class*, Diarthrosis; *Sub-Class*, Ginglymus. The **Bones** entering into its formation are—1. The *Femur*, with its **trochlear** surface, which is *highest* and most prominent on the *outer* side; and the articular surfaces of the **Condyles**, of which the inner is the more elongated from before backwards. 2. The *Tibia*, with its two surfaces, of which the internal is the longest, narrowest, and deepest—the external being the reverse. 3. The *Patella*, with its seven facets. The **Synovial Membrane** is the largest in the body. It forms a large *cul-de-sac* beneath the extensor muscles of the thigh, extending upwards for one or two inches above the articular surface. At the sides it passes beneath

the vasti and ascends higher on the *inner* than on the outer side of the limb beneath these muscles (being the reverse, therefore, of the articular surfaces); it also covers the lateral aspects of the tuberosities of the femur for about half their extent, extending further back on the inner condyle. This large pouch is supported during the movements of the joint by the sub-crureus muscle, which is inserted into its upper part. Above the pouch there is sometimes an independent bursa extending upwards for another inch, but very often it communicates with the cavity of the knee joint. The membrane also covers both surfaces of the semi-lunar cartilages, and on the back part of the external one sends a tubular prolongation round the tendon of the popliteus muscle for some distance. It further surrounds the crucial ligaments by tubular prolongations, lines the whole interior of the capsule, and lastly very frequently extends into the superior tibio-fibular articulation. The **Arteries** are *seven* in number—anastomotica magna, five branches from the popliteal artery, and the recurrent branch of the anterior tibial. The **Nerves** are nine in number — branches from the obturator, from the nerve to the vastus externus, and from the nerve to the vastus internus (both from the anterior crural), three from the internal popliteal, two from the external popliteal, and the recurrent articular from the termination of the same nerve.

The **Ligaments** of this joint are very numerous, and are divided into internal and external sets. **External Ligaments.**—1. The internal lateral, a broad flat band, from the back part of the inner tuberosity of the femur to the inner tuberosity and upper part of the shaft of the tibia. Beneath it pass the inferior internal articular vessels. 2. The external lateral—the *long* part, passing from the back part of the outer tuberosity of the femur to the outer part of the head of the fibula. It pierces the tendon of the biceps, and under it pass the tendon of the popliteus and the inferior external articular vessels. The *short* part is more posterior, and is attached below to the apex of the styloid process of the fibula. 3. The posterior ligament, or ligament of Winslow, a broad flat band principally derived from the tendon of the semi-membranosus. 4. The ligamentum patellæ, the continuation of the tendon of the quadriceps extensor cruris, passing from the apex of the patella to the lower part of the tubercle of the tibia; between

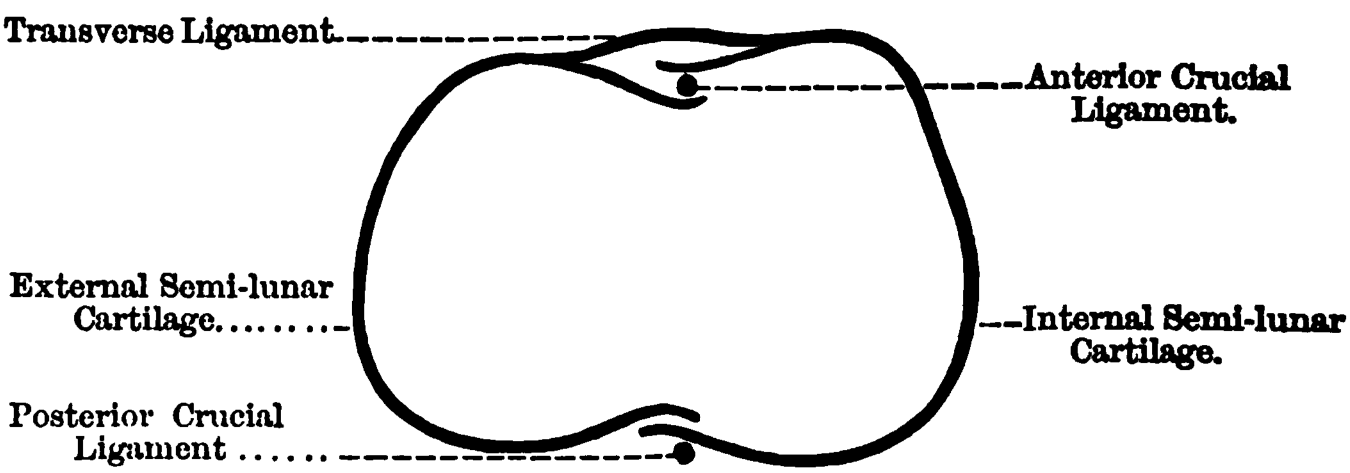
it and the upper part of the tubercle is a small bursa, and a large mass of fat (the *infra-patellar* pad) separates it from the synovial membrane of the knee joint. 5. The capsular, which is a strong fibrous membrane filling up the gaps left by the other ligaments, and is strengthened by fibres from the various muscles surrounding the joint. **Interior Ligaments.**—1. *Crucial*, anterior and posterior —(*a*) The *antero-external* is attached below to the inner part of the pit in front of the spine of the tibia; above, to the inner and hinder part of the external condyle of the femur. Its direction is upwards, backwards, and outwards; it is rendered tense when the joint is extended, when the leg is rotated inwards, and in cases where the tibia tends to be displaced forwards. (*b*) The *postero-internal* is attached below, to the back of the pit behind the tibial spine; above, to the fore-part of the inter-condyloid hollow and side of the inner condyle. Its direction is upwards and a little forwards; and it is made tense under conditions opposite to those that tighten the anterior ligament. 2. The *semi-lunar cartilages* —(*a*) The *internal* forms almost a semi-circle, and embraces the ends of the external. Its anterior end is attached to an impression towards the front part of the internal articular surface; its posterior end is attached to the inner edge of the hollow behind the spine of the tibia along with the posterior crucial ligament. (*b*) The *external* forms about three-fourths of a circle, and its anterior and posterior ends are interposed between the attachments of the internal cartilage, in front of, and behind the spine of the tibia; this cartilage is more movable than its fellow and less firmly attached to the head of the tibia. 3. The transverse ligament, which passes between the two cartilages. 4. The coronary ligament, which connects the convex borders of the cartilages with the head of the tibia. 5. The ligamentum mucosum, which is simply a process of synovial membrane. 6. The ligamenta alaria, its fringed borders.

The following **Structures** are found upon the **Head of the Tibia** from before backwards (Fig. 76):—(1) Transverse ligament; (2) anterior extremity of internal semi-lunar cartilage; (3) anterior crucial ligament; (4) anterior extremity of external semi-lunar cartilage; (5) posterior extremity of external semi-lunar cartilage; (6) posterior extremity of internal semi-lunar cartilage; and (7) the

posterior crucial ligament. The key to the position is to remember that the internal cartilage embraces both ends of the external, and that the anterior crucial is placed *between* the two anterior ends, but the posterior is behind both the posterior ends.

Fig. 76.

HEAD OF LEFT TIBIA.



The **Movements** of this joint are in some respects peculiar:—1. It is not a pure hinge-joint, but has in addition a gliding and rolling movement. In these movements the semi-lunar cartilages (which may be regarded as inter-articular fibro-cartilages) form movable and accurately fitting wedges. It is of great practical importance to keep this gliding movement in mind in the case of distortion of the joint due to strumous arthritis; in this disease the joint becomes markedly flexed, the tibia lying against the posterior part of the condyles having glided backwards. For this reason forcible straightening can do no good, unless in recent cases, as it will not restore the bones to their normal position, the tibia retaining its backward displacement, even after the leg is straightened. 2. The movement is through an oblique plane, the axis of the femur is downwards and inwards, but when the leg is flexed it is parallel with the thigh. 3. There is a movement of rotation at the completion of extension which is called the "locking" or "screwing home" of the joint. 4. When the knee is partly flexed, the joint admits of internal and external rotation. Another point worthy of notice is the movements of the patella on the articular surface of the femur. This is a movement partly of gliding and partly of co-aptation. The patella has seven facets on its articular surface—three pairs, and one internal

perpendicular facet. When the knee is extended, as in the erect position, the two inferior facets are in contact with the upper part of the trochlear surface of the femur; in semiflexion, the middle facets come into contact with the femur; in still greater flexion, the superior pair are brought into contact; while in extreme flexion, the patella leaves the trochlear surface of the femur altogether, and the internal perpendicular facet then lies in contact with the outer margin of the inner condyle. Further, at the completion of extension, there is a slight rotation outwards to "lock" the joint; and, at the beginning of flexion, there is a slight rotation inwards of the leg and foot to "unlock" it. The centre of gravity of the body, in the erect attitude, falls in *front* of the axis of motion of the knee joint, and there is a tendency, therefore, to over-extension; but this is impossible, because of the tension of the lateral, posterior, and *anterior* crucial ligaments (the *posterior* crucial being tightened in flexion). In this way the erect attitude is maintained without the expenditure of muscular energy. Professor HUMPHRY states that the semi-lunar cartilages do not follow the tibia in the movements of rotation (pronation and supination), these movements taking place between the head of the tibia and the cartilages, while the chief movements of the joint take place between the femur and the cartilages. This probably explains the production of the "Internal Derangement of the Knee Joint," which is usually produced during some sudden wrench of the leg, that is of the tibia on the femur, or of the femur on the tibia. **Flexors.**—*Direct*—(1) Biceps, (2) semi-tendinosus, (3) semi-membranosus, and (4) popliteus. *Indirect*—(1) Gastrocnemius, (2) plantaris, (3) sartorius, and (4) gracilis. **Extensors.**—Quadriceps extensor cruris (formed by the two vasti, the rectus femoris and the crureus). **External Rotator.**—(When the limb is partly flexed)—The biceps as a whole, but especially its short head. **Internal Rotators.**—(1) The popliteus—(this is the chief one, but it only acts when the knee joint is flexed, and the tendon of the popliteus lying in its groove), (2) semi-tendinosus, (3) semi-membranosus, (4) sartorius, and (5) gracilis. To **lock home** the joint at the completion of extension—The extensor muscles as a whole cause a slight rotation outwards. To **unlock** the joint at the commencement of flexion—(1) The sartorius, (2) gracilis, and (3) semi-tendinosus.

The different movements of the joint are limited in something like the following manner:—**Flexion** is checked by the contact of the soft parts of the leg and thigh; but during this movement the posterior crucial ligament and the ligamentum patellæ are also tightened, but all the other ligaments are relaxed. **Extension** is limited by the lateral, the posterior ligament, and the anterior crucial; during this movement the posterior crucial and ligamentum patellæ are relaxed. When the limb has been brought into a straight line, *over-extension* is mainly checked by the tension of the posterior crucial and posterior ligaments. Forcible over-extension of the joint may rupture the posterior crucial, *e.g.*, when the leg is supported horizontally on a chair and some heavy weight falls forcibly upon the anterior aspect of the knee. **Internal rotation**, or pronation (in the semi-flexed position of the knee), is checked by the *anterior* crucial ligament. **External rotation**, or supination, is checked by the *posterior* crucial. The crucial ligaments are also important agents (probably the chief) in the prevention of lateral movements of the joint; hence, in cases where the bones move laterally in the extended position of the limb, there is good reason to believe that the crucial ligaments are destroyed.

In effusion into the joint, as in **Acute Synovitis**, the swelling assumes a horse-shoe shape, and first shows itself at the sides of the ligamentum patellæ, because at these points the synovial membrane is least supported and nearest the surface. The swelling gradually extends upwards under the quadriceps extensor, to the extent of two or three inches above the upper border of the patella, the swelling being higher on the *inner* than on the outer side of the limb. Fluctuation is readily detected by placing the fingers and thumb of one hand over the pouches at each side of the ligamentum patellæ and pressing on the large supra-patellar pouch with the other; and if there is much fluid the patella is floated up off the surface of the femur, and by firm, sudden pressure it may be made to tap against it, provided the fluid is not in too small quantity, or if in large quantity, not too tense, and that the quadriceps extensor is relaxed. This floating of the patella is a very valuable sign of effusion into the joint, and may be detected before either fluctuation or swelling is very evident. To obtain this test the knee must be extended and the hip flexed to relax the quadriceps extensor and allow the

patella to lie free; in cases where the amount of effusion is small, the large pouch above the patella should be emptied by pressing over it with the palm of the hand, as this will press what fluid there is more directly under the patella. The position of the limb is one of moderate flexion, combined with external rotation of the head of the tibia, as in this position the cavity holds most fluid, and it, at the same time, relaxes the more powerful ligaments of the joint (posterior ligament, posterior crucial, and lateral ligaments). Should, however, the joint remain long in this position, there is a tendency for the head of the tibia to be partly dislocated backwards and rotated outwards, from the continued action of the hamstrings, conjoined with softening and yielding of the crucial and lateral ligaments; and for the same reasons there will be slight lateral movement of the joint.

In effusion into the *prepatellar bursa* (**Housemaid's Knee**) the swelling does not assume the shape of the synovial cavity, but forms a prominent globular swelling in front of the patella, thus obscuring it; whereas, in synovitis, this bone can readily be felt surmounting the swelling. Above the synovial pouch of the knee joint there is very frequently a *separate bursa* about an inch long, between the quadriceps and the femur, and which may become filled with effusion, but without affecting the knee joint; very frequently, however, it communicates with the synovial membrane of the knee joint.

The following muscles **act on both Hip and Knee Joints**:—(1) The biceps, (2) the semi-membranosus, (3) the semi-tendinosus, (4) the rectus femoris, (5) the sartorius, (6) the gluteus maximus (through the *ilio-tibial band*), (7) tensor fasciæ femoris (through the *ilio-tibial band*), and (8) the gracilis. It is evident, therefore, that in disease of either the hip or knee joints, *both* will require to be kept rigid, in order that the diseased one may be at rest.

There are three circumstances which tend to make the knee joint insecure—(1) The configuration of the articular surfaces of the bones; (2) the fact that it is between the two longest bones in the body, and, therefore, powerful leverage is brought to bear upon it; and (3) its great mobility. Neverthel
this joint is rare, its great strength being
ligaments.

DISLOCATION OF THE KNEE JOINT.

This is a rare form of accident, for reasons already stated, and when it does occur, it is usually complicated with such injury to the popliteal vessels as to necessitate amputation. Other complications are also likely to arise from the force required to dislocate it, such as rupture of ligaments and muscles, and gangrene may result, or the joint may fall into a state of suppurative or destructive inflammation, so that dislocation of the knee joint is more liable to complications than any other joint. Diastasis of the condyloid part of the femur in young children may resemble dislocation of the knee joint. It may be dislocated to either side forwards or backwards.

1. The **Lateral** dislocations are most common and always incomplete, and usually combined with a certain amount of external rotation, due to the action of the biceps. One or other condyle slips over to the opposite half of the tibial surface; the knee is always slightly flexed. To **reduce,** flex the thigh on the abdomen, extend the knee, and rotate slightly.

2. **Backwards.**—This may be either complete or incomplete. If complete, the ligamentum posticum and the posterior crucial ligament are ruptured; the limb is shortened and semiflexed, and the head of the tibia can be felt in the ham.

3. **Forwards.**—This form occurs more frequently than the last-named dislocation. It is more dangerous also, from pressure on the popliteal vessels by the lower end of the femur, which is found projecting into the popliteal space. There is shortening of the limb and a certain amount of rotation. To **reduce,** the thigh is semiflexed and held firmly by one assistant, while another makes extension from the ankle joint, and the Surgeon manipulates the bones into position. In all cases of dislocation, the joint must be kept at rest for two or three weeks by lateral splints. In cases which resist all the ordinary means of reduction, division of the lateral ligaments has been practised.

4. **"Subluxation" of the Knee** (HEY'S "*Internal Derangement of the Knee Joint.*")—It is due to partial dislocation of the *internal* semi-lunar cartilage usually; the cartilage slips away from its proper position under the internal condyle, so that the surfaces of the

tibia and femur are brought into direct apposition. **Cause.**—The displacement of the internal cartilage is caused either by a wrench outwards of the foot, or, the foot being fixed, of the body inwards; and the external is displaced by movements of an opposite nature, *i.e.*, a wrench of the foot inwards, or of the body outwards. There is sudden, severe, sickening pain felt in the knee, and the joint remains semiflexed. The edge of the cartilage can sometimes be felt projecting under the skin. To **reduce,** flex the joint, and when the patient is off his guard, forcibly extend, rotating slightly, either to the inner or the outer side, and at the same time press the thumb firmly on any tender spot. When the cartilage is reduced the power of extending at once returns. The synovitis induced by the accident must be treated on general principles; after it has subsided the leg must be used freely. This condition must be distinguished from that due to a loose body in the joint.

Displaced Cartilage.	Loose Body.
1. In the first instance is caused by some sudden wrench or twist when the knee joint is partially flexed.	1. The impaction of a loose body occurs during the ordinary movements of flexion and extension.
2. May feel a hollow or projection over the displaced cartilage, and the pain always felt at the same spot.	2. The loose body cannot be felt when impacted, and the site of the pain may vary from time to time.
3. Passive movement is easy, short of extreme limits.	3. The joint is locked and rigid.
4. When any projection can be felt, matters have gone wrong in the joint.	4. When the loose body is felt externally, the joint is all right.
5. Is a chronic condition.	5. Is always acute.
6. Radical Cure.—Some means to prevent pronation and supination of the joint for a long period till the cartilage adheres to the head of the tibia again. In suitable cases Mr ANNANDALE opens the joint and stitches the displaced cartilage to the head of the tibia.	6. Radical Cure.—Removal of the foreign body through a direct incision into the joint with strict antiseptic precautions. Before making the incision the "body" should be transfixed with a long needle, otherwise it may slip away into the cavity and cause much trouble.

THE PATELLA.

This bone may be dislocated:—

1. **Outwards.**—This is the most common form, from the slope of the femur and quadriceps extensor, which pass downwards and inwards, making an angle with the ligamentum patellæ, which passes vertically downwards. When, therefore, the quadriceps is suddenly brought into play it tends to assume a straight line with the ligamentum patellæ, and jerks the patella itself outwards. The **causes**, therefore, are sudden muscular contraction, especially in those who have a tendency to knock-knee, or a blow on the inner side of the patella during *extension*—a similar blow during flexion would cause fracture. The patella rests on the outer surface of the external condyle with its inner margin directed forwards. The leg is usually slightly flexed; very frequently the dislocation is only partial.

2. **Inwards.**—This form is almost unknown. To **reduce** *lateral* dislocations—Place the patient on his back, flex the thigh on the abdomen, and extend the knee joint, so as to relax the quadriceps extensor, and then depress the edge of the patella which is further from the middle line, so as to raise the other edge and free the bone, when the quadriceps will at once pull it into position.

3. **Vertically.**—Usually the outer (MALGAIGNE), sometimes the inner edge, of the patella is twisted into the inter-condyloid notch, and there fixed. The joint is completely extended. It is usually **caused** by sharp blows or severe falls on one side of the patella. To **reduce** is often a difficult matter, probably from the wedging of the bone in the notch, or else from its being held by a slit in the capsule. Chloroform will be necessary, so as to paralyse the muscles, when flexion, combined with sudden extension and rotation of the tibia, will probably replace the bone. Division of ligaments and tendons should be avoided, as the division does no good, and may do a great deal of harm.

4. **Upwards.**—This can only occur when the ligamentum patellæ is ruptured, or torn from its attachment, when the quadriceps extensor pulls the bone upwards. It may also be displaced **downwards,** from rupture of the quadriceps extensor. The **Treatment** is the same as *that for* fractured patella *(quod vide).*

THE ANKLE.

The Ankle Joint.—*Class*, Diarthrosis; *Sub-Class*, Ginglymus. **Ligaments**—(1) The anterior, (2) posterior—these two are very thin; (3) internal lateral or deltoid, from the apex of the internal malleolus to the scaphoid, os calcis, and astragalus; and (4) external lateral, which consists of three strong fasciculi—(*a*) the *anterior* passes from the anterior part of the external malleolus to the front part of the astragalus; (*b*) the *middle* passes from the tip of the external malleolus to the outer surface of the os calcis; and (*c*) the *posterior* passes backwards horizontally from the pit on the inner side of the malleolus to the posterior surface of the astragalus. The **Nerves** of the joint are derived from the internal saphenous and anterior tibial. The first is derived originally from the lumbar plexus, the second from the sacral.

Movements.—The movements at the ankle joint are chiefly flexion, and extension, and dorsiflexion. The normal position of the foot is supposed to be at right angles to the leg; *extension* is pointing the toes, *flexion* is bringing the foot back again to a right angle, and *dorsiflexion* is when the foot passes the right angle and its upper surface approaches the front of the leg. There is also a certain amount of movement from side to side when the foot is extended, because the posterior part of the articular surface of the astragalus is narrower than the anterior, but in the *erect* position there is no lateral movement possible. There are other two movements spoken about as occurring at the ankle—viz., eversion and inversion; the first of these movements is not very free, the second form is much freer. In **Eversion**, the outer border of the foot is raised and drawn outwards. In the production of this form of club-foot *(talipes valgus)* there is, in the first instance, an obliteration of the arch of the foot, so that the sole becomes perfectly flat *(talipes planus*, or flat-foot), and as the disease advances, eversion of the foot takes place. The flattening of the foot is due to the relaxation of the ligaments that support the arches of the foot; the ligaments that support the *transverse* arch are chiefly the interosseous ligaments, between the cuneiform and the cuboid bones; those that support the *longitudinal* arch are—(1) the long plantar ligament (the inferior calcaneo-cuboid); (2) the

short plantar ligament (the short calcaneo-cuboid); (3) the inferior calcaneo-scaphoid ligament, which supports the head of the astragalus; (4) the plantar fascia also assists to maintain the arch; (5) the tendon of the tibialis posticus; and (6) the tonic contraction of the muscles of the sole. When these structures are relaxed the head of the astragalus passes downwards, forwards, and inwards, producing the condition known as *flat-foot*, which is often associated with a peculiar straight and rigid condition of the great toe at the metatarso-phalangeal articulation, and which has been designated "hallux rigidus." **Inversion** is a much freer movement. It takes place at three points—(1) to a very slight extent at the ankle joint proper; (2) a little at the articulation between the astragalus and the os calcis; but chiefly at (3) the transverse articulation of the foot, *i.e.*, at the astragalo-scaphoid and calcaneo-cuboid articulations. We have an example of this form of movement in *talipes varus*, where the foot is twisted inwards and the sole is contracted. **Flexors** of the ankle joint.—*Direct*—(1) The tibialis anticus, (2) the peroneus tertius. *Indirect*—(1) The extensor longus digitorum, and (2) the extensor proprius hallucis. **Extensors.**—*Direct*—(1) The muscles of the calf (gastrocnemius, soleus, and plantaris); (2) the tibialis posticus; (3) the peroneus longus; and (4) the peroneus brevis. *Indirect*—(1) The flexor longus digitorum; and (2) the flexor longus hallucis. Note that the indirect *flexors* of the ankle joint are *extensors* of the toes; while the indirect *extensors* are *flexors* of the toes. **Evertors.**—(1) The peroneus longus, (2) the peroneus brevis, and (3) the peroneus tertius. **Invertors.**—(1) The tibialis anticus, and (2) the tibialis posticus. It should be noted that in ordinary extension movements of the ankle, when a person is sitting or lying, the muscles of the calf are not used, but the movement is performed by the flexors of the toes (indirect extensors). It is only when the movement is resisted, or when greater force is required that the muscles of the calf are used. *Flexion* of the joint is limited by the posterior part of the deltoid ligament, by the posterior fasciculus of the external ligament, by the posterior ligament, and by the contact of the head of the astragalus with the tibia. *Extension* is limited by the anterior fibres of the deltoid ligament, anterior and middle fasciculi of the outer, by the anterior ligament, and by the contact of the astragalus with the tibia behind.

The position of the **Malleoli** and the **Scaphoid Tubercle.**—The internal malleolus is more prominent and more anterior than the external; but the external extends lower down, and its tip is about half-an-inch behind, and half-an-inch below the tip of the internal. The tubercle of the scaphoid is nearly two inches in front of the internal malleolus, and the sustentaculum tali is an inch below it; between these two points is the inferior calcaneo-scaphoid ligament and a band from the tibialis posticus—the position of the early pain in flat foot. In effusion into the joint, as in **Acute Synovitis,** the swelling first shows itself in front beneath the anterior tendons, and at each side in the interval between the anterior edges of the lateral ligaments and the tendon of the peroneus tertius on the outer side, and that of the tibialis anticus on the inner; further, when looked at from behind the joint has an appearance of increased width, from filling up of the hollows on each side of the tendo achillis. In severe cases it may be possible to detect bulging of the thin posterior ligament, and obtain fluctuation on the two sides of the tendo achillis. The foot usually assumes a position of slight extension (pointing of the toes), and some amount of inversion. In effusion into the *bursa beneath the tendo achillis* there is a swelling about an inch above the point of the heel, the tendon is more prominent and fluctuation may be obtained from side to side.

DISLOCATIONS.

By dislocation of the ankle is meant displacement of the trochlea of the astragalus, from the tibio-fibular mortise, the astragalus still retaining its natural relations with the rest of the foot. It may be dislocated in five directions—outwards, inwards, backwards, forwards, and upwards (in the order of frequency). They are usually *caused* by some violent and sudden twist of the foot, as treading on the edge of the kerb-stone, or alighting from a height upon a lower level than expected, with some part of the foot, but not flatly on the sole. The antero-posterior are produced by the sudden arrest of the foot during some violent impulse of the body, as in leaping from a carriage in motion, or by some great force applied to the foot when the leg is fixed.

1. **Outwards.**—**Caused** by a forcible twist of the foot outwards, as in suddenly slipping off the edge of the kerbstone, when the weak fibula first snaps, and then the internal lateral ligament of the ankle, or else the tip of the internal malleolus is torn off. (*a*) The **Incomplete Form** *(same thing as "Pott's fracture").* In French works on Surgery this injury is called "*dislocation of the foot backwards, with fracture of the fibula;*" in English text-books, on the other hand, it is called "*Pott's fracture, with backward displacement of the foot.*" The astragalus is partly displaced from the tibia by a rotation on its own horizontal axis, so that the outer edge of its superior articular surface is higher than the inner, and rests against the under surface of the tibia. It is always caused by indirect violence, usually from a twist of the foot outwards, or else, the foot being firmly jammed, by the body falling outwards over the ankle. The displacement of the foot is usually a double one—outwards and backwards. The fractured point of the fibula is from one and a half to three inches or more above the external malleolus, that is, through the upper part of its triangular subcutaneous surface. The foot is everted principally by the force that caused the dislocation, but also by the three peronei muscles, as well as the weight of the limb, so that the foot almost looks directly outwards, the outer border being raised, and the heel drawn up by the muscles of the calf. There is a marked projection on the inner side, due to the internal malleolus; and on the outer side, in the site of the fractured fibula, there is a depression, as the broken ends are forced inwards. The strong inferior tibio-fibular ligament is not ruptured. (*b*) The **Complete Form** *(same as "Dupuytren's fracture").* In this form either the inferior tibio-fibular ligament is torn, or else a strip of the tibia, to which it is attached, is torn off, while the deltoid ligament escapes rupture. It is believed that the forcible eversion of the foot causes the outer border of the astragalus to act as a wedge, separating the lower end of the fibula from the tibia, the interosseous ligament usually tearing off its attachment to the tibia. The trochlear surface of the astragalus is completely displaced to the outer side of the bones of the leg and drawn upwards; the internal malleolus is sometimes forced through the skin, thus making the dislocation compound. There is increased breadth of the ankle, with

shortening of the leg, but very little eversion of the foot. The internal malleolus is further down and more prominent than it should be; the external malleolus goes up with the astragalus, and is also prominent but too high. The whole foot has a tendency to be rotated outwards.

2. **Inwards.**—This is **caused** by violence, the reverse of that which produced the previous dislocation. It is much rarer, however, as the powerful internal malleolus resists the twist and very frequently, therefore, the only result is a "sprained" ankle. Should this dislocation occur, the tibia, and sometimes the fibula as well, is broken from the sudden wrench given to the strong external lateral ligament, which, rather than give way itself, often snaps the fibula, the broken ends of which in this case are displaced outwards. It is always incomplete, and the astragalus rotates on its antero-posterior axis. The sole of the foot is inverted, and the external malleolus is very prominent and almost touches the ground, and there is a depression on the opposite side of the ankle.

3. **Backwards.**—It is **caused** by jumping from a carriage in motion, or falling backwards while the foot is fixed; the foot being fixed the inertia of the body carries the leg bones forwards. It may be complete or incomplete; if complete, the anterior and posterior ligaments are torn, and the lower end of the tibia rests on the neck of the astragalus and scaphoid, with the trochlear surface of the astragalus behind it. The whole foot is fixed, and the anterior part seems too short, and the heel too long with a depression above it; the tendo achillis is tense, and the toes are pointed downwards. The lower ends of the tibia and fibula are prominent in front; but the fibula is broken about the same place as in POTT's fracture, and the internal malleolus is also very frequently broken.

4. **Forwards.**—Less common than the last. It is usually incomplete, the tibia resting on some part of the articular surface of the astragalus, and not entirely behind that bone. The foot is elongated, and the heel shortened and less prominent. The space in front of the tendo achillis is occupied by a hard mass—the ends of the tibia and fibula; both the malleoli are usually broken. The tendo achillis is lax, and not so prominent as usual.

To **reduce** these dislocations, flex the leg on the thigh, extend the ankle joint so as to relax the muscles of the calf and the tendo achillis; one assistant must now hold the thigh firmly, another seizes the foot and pulls in the direction of the long axis of the leg, while the Surgeon, by manipulation and pressure, endeavours to replace the bone. In difficult cases it may be necessary to divide the tendo achillis, and probably always at once in the forward variety. After reduction, the leg is to be placed in the box splint (see "Fracture of the Bones of the Leg"). In some cases it may be necessary to resect or even amputate.

5. **Upwards.**—In this case the two bones are separated, the inferior tibio-fibular ligaments being ruptured and the astragalus forced up between them; the anterior and posterior ligaments are torn. It is **caused** by falls on the feet from a great height, the foot being at right angles to the leg, and neither flexed nor extended; the characteristic appearance is the increased width of the ankle joint, due to the separation of the malleoli. It is to be **reduced** in a similar way to that adopted in the other cases of dislocation. Sometimes it may be found impossible to do it; nevertheless, by patience, a useful foot may result.

OTHER DISLOCATIONS OF THE FOOT.

Dislocations of the Astragalus.—In all dislocations of this bone the malleoli are nearer the sole than they should be, but are not separated from each other more than the normal distance, and there is little, if any, alteration in the length of the heel or of the anterior part of the foot. The astragalus is thrown out of proper relation, both with the bones of the leg and the other bones of the tarsus; there is an entire loss of flexion and extension at the ankle joint. The ligaments connecting the astragalus with the other bones of the ankle are torn.

1. **Forwards.**—The most common form. The astragalus is shot forward like an orange pip from between the finger and thumb, and rotated slightly at the same time—usually to the outer side. It may be complete or incomplete. A swelling is noticed to one or other side, which is the round, globular head of the astragalus covered by tense skin; it may be possible to distinguish the outline

of the head, as well as the saddle-shaped articular surface. This dislocation is usually **caused** by a fall or twist on the extended foot; it is very often compound.

2. **Backwards.**—This is **caused** by falls or twists on the flexed foot; it is rare. There is a hard prominence felt just above the heel, between the tendo achillis and the malleoli. The foot seems shorter, and there is a prominence in front caused by the ends of the tibia and fibula.

3. **Lateral.**—If complete, must always be compound. If to the outer side, the foot is turned inwards, and there is a great projection of the external malleolus. If to the inner side, the appearances are reversed.

4. **Version.**—A rotation of the astragalus on its horizontal or vertical axis. The history of severe injury, and the loss of movement must guide. To **reduce,** give chloroform and attempt reduction as in the previous dislocations, by flexing the leg on the thigh, extending the foot, and then by extension, counter-extension, and manipulation, forcing the bone back to its place. It may be advisable to divide the tendo achillis or any other *tense* tendon, such as the posterior tibial. In impossible cases, put up in the best position, wait and watch, and act accordingly. Should the skin threaten to slough over the head of the bone, it must be excised. Do not be in too great a hurry to amputate.

Subastragaloid Dislocations.—These are dislocations at the calcaneo-talo-scaphoid articulation. The astragalus maintains its normal relations with the tibia and fibula, whilst the rest of the foot is partially or completely disarticulated from it; the malleoli are not so depressed as in dislocation of the astragalus, nor is the rigidity of the joint so great. The *foot* may thus be displaced forwards, backwards, or laterally; the usual form is backwards, from a strain or twist. It is seldom, however, directly backwards; the foot is usually at the same time twisted outwards or inwards.

If **backwards and outwards,** the foot is everted and abducted, the sole looks outwards, and there is great prominence of the heel; the inner malleolus and head of the astragalus are prominent, but the outer malleolus is not so prominent.

If **backwards and inwards**, the symptoms are reversed. The ligaments connecting the astragalus with the os calcis and scaphoid are more or less completely ruptured; the malleoli are often fractured, and the lateral ligaments of the ankle joint more or less torn.

Laterally.—These are usually incomplete and often compound; they are more common than the antero-posterior forms. In the *inward* form the appearance resembles that of *talipes varus*—the foot is inverted, its inner border is raised, shortened, and rendered concave, while its outer border is lengthened and convex. The head of the astragalus and outer malleolus form a marked projection on the outer side of the foot; the inner malleolus is buried, and the whole limb seems shorter than natural. In the *outward* form the reverse holds true. The appearance resembles that of *talipes valgus;* the foot is everted, its outer border is raised, shortened, and concave, while the inner is lengthened and convex. The outer malleolus is buried, while the tibia and head of the astragalus form a marked projection on the inner side.

The **Treatment** must be conducted on the same principles as in dislocations of the astragalus.

CHAPTER XXIII.

FRACTURES.

Before describing fractures in detail, I will give a short account of the

ANATOMY OF A BONE.

Taking a long bone, such as the femur, we see it consists of a shaft and two extremities. The shaft consists of a thick layer of compact tissue externally, with a thin lining of cancellous tissue, and encloses the medullary canal, and this in turn contains the yellow marrow, which consists chiefly of fat and blood-vessels; in some cases of fracture this fat passes into the circulation and causes fatty emboli in the pulmonary capillaries. The articular ends of the bone consist almost entirely of cancellous tissue, with a thin covering of compact bone which gradually becomes thinner until it ceases at the margin of the articular cartilage; this spongy tissue contains the *red* or *blood-forming marrow*, although the larger cancelli contain principally yellow marrow. It is in this part also that the "*myeloid*," or "giant cells," are found, which probably explains their presence in sarcomatous tumours of the articular ends of bones.

The **Periosteum.**—This is a fibrous membrane, forming a complete external covering to the bones, except where they are covered with cartilage and at the insertion of strong tendons. It consists of two layers—(*a*) an **outer layer**, composed of elas and white fibrous tissue, running longitudinally for the most p and (*b*) an **inner layer** which is soft and cellular, and in wh the blood-vessels break up before entering the bone. The c next the bone are called *osteoblasts*, or bone-forming cells, a the whole inner layer is sometimes called the *osteogenetic* laye

this layer is also prolonged into the Haversian canals. In young subjects it is very cellular and soft, but as age advances it becomes more fibrous and contains fewer osteoblasts; in amputations performed on young persons, therefore, one must be very careful, after the bone is divided, not to strip back the periosteum by pulling on the flaps. Further, since the periosteum, from the arrangement of its fibrous layer, tends to split *longitudinally* and not circularly, it is necessary in subperiosteal resections, not only to divide the periosteum *longitudinally*, but to make transverse cuts as well, otherwise the membrane will strip up far beyond the part required; this is well shown in resections of the ribs, the upper part of the femur, and in many other situations. The Haversian canals contain blood-vessels for the nourishment of the bone, fine connective tissue, lymphatics, and nerves, and a lining of osteoblasts or bone-forming cells. In the medullary canal of a long bone the vascular fibrous tissue is condensed into a kind of membrane called the *endosteum*. The periosteum serves a double purpose—(*a*) from it the compact tissue of the shaft receives its principal blood supply; and (*b*) by it the shaft of the bone increases in thickness, while the medullary canal is being hollowed out; in fact, the entire shaft of the permanent bone is produced by the periosteum, for the part originally formed in cartilage is all removed to form the medullary canal.

The bones increase *in length* by progressive ossification of the layers of cartilage which intervene between the ends of the shaft and the epiphyses; growth continues, therefore, as long as the cartilage remains unossified. Sometimes, from an injury causing separation of the epiphysis, or setting up simple or tubercular inflammation, one epiphysis may unite sooner than its fellow of the opposite limb, and in this way one limb will gradually become shorter than the other; this is of special importance in cases of injuries to the hip joint in young people (up to eighteen years). But bones also grow slightly in length by interstitial deposit; this is well seen in cases of interstitial ostitis attacking a bone during the growing period. In this way one limb gradually becomes longer than its fellow; the bone is usually at the same time thickened, as well as lengthened, from the presence of *periostitis*; but the periostitis, while it accounts for the *thickening*, could not account for the

lengthening of the bone. In young bones the periosteum is always firmly adherent to the epiphyseal cartilages. The mode in which bones grow in length was first proved by HALES, HUNTER, and others, who introduced shot, or ivory pegs, at definite distances into the shaft of the growing bone of a common fowl, and examined them a fortnight or three weeks later; it was then found that the distance between the two pegs was only half as much increased as the distance between a given peg and the end of the bone.

The Nutrition of a Bone.—A long bone has three sources of blood supply :—

1. The **articular ends** are supplied by the articular arteries, being cut off from the shaft proper in early life by the epiphyseal cartilage. Hence it is, therefore, that the articular ends of the bones seldom perish in the disease known as *diffuse infective suppurative periostitis* (= the so-called "*acute necrosis,*" which probably also includes the *circumscribed* and less extensive form, as well as the *diffuse*), while the whole *shaft* may perish, from epiphyseal line to epiphyseal line. This is very fortunate, for were it otherwise the joints would be speedily involved, and amputation would be required almost in every case; whereas, as a matter of fact, amputation is seldom required, because the pus rarely finds its way into the articulation. When this unfortunate accident occurs, it is because the pressure of the septic pus separates the strong attachment between the periosteum and the epiphyseal cartilage, and thus finds its way into the joint; the importance, therefore, of *a free and early incision down to the bone* will be at once evident. The veins, in the spongy tissue of bone especially, are peculiar—*e.g.*, in the diploë, vertebræ, ends of long bones, etc. In the first place, they run in canals by themselves; and, in the second, their walls are very thin, and do not collapse when the bone is broken across, since they are attached to the bony tissue around them, and they often contain pouch-like dilatations. Further, they are exceedingly numerous. Now, these facts explain two interesting pathological points—(1) How these open mouths in fracture of the bone readily take up floating oil globules, giving rise to fat embolism. This is most apt to occur in cases where the bone is broken into a number of fragments (*comminuted*) and usually from twenty-four hours to three days after the accident;

the signs resemble acute lobar pneumonia. There is sudden dyspnœa, rapid, laboured breathing and cyanosis, rapid weak pulse and turbulent heart, but on auscultation the air is heard to enter and leave the lungs freely; sometimes fat is observed floating on the surface of the urine. (2) It also helps towards an explanation of the origin of pyæmia—*e.g.*, following compound fractures of the bones of the head. The mouths of the veins are, as I said, patent and non-collapsable, and the usual steps of the process are probably the following—(*a*) Osteo-phlebitis with thrombosis in the open mouths; (*b*) this thrombus is septic, or readily becomes so, and therefore (*c*) tends to break down (= the old "*suppurative phlebitis*"), and (*d*) forms minute septic emboli, which are carried far and wide by the blood-stream, and are caught at points where the vessels break up into capillaries, as in the lungs and liver, and when the little plugs come to rest, the micro-organisms they contain begin to multiply, and hence we have (*e*) the secondary abscesses. But the same series of changes may occur even though the veins in the bone be not torn across, as their walls are so thin that septic processes readily spread from the bone into the vein, forming a true septic phlebitis, as in idiopathic osteo-myelitis, which often exists along with "acute necrosis."

2. The **shaft** of a long bone is supplied chiefly by the periosteum. If we look at the surface of the shaft of a long bone we can see a large number of minute longitudinal grooves, in which the vessels lie before entering the substance of the bone; at the ends of the grooves, by the aid of a pocket lens, we can also see very fine oblique openings—in fact, the ends of Haversian canals, into which the vessels pass. It is usually taught that if the periosteum be stripped from a bone the bone will die, but this does not *necessarily* follow, and for various reasons—(1) If the periosteum is not raised *too far* from the bone, the vascular connections will not be torn, because many of the capillaries run for some distance along the surface of the bone, in the grooves already mentioned, before they enter the Haversian canals, and the effusion between the bone and the periosteum simply raises them from the horizontal to the vertical position; further, the vessels can be pulled for some distance out of the Haversian canals without tearing across. (2) Then again, even if the vascular connections are torn across

in the first instance, if the separation of the periosteum from the bone be not *too long continued*, the periosteum may fall down and become again connected with the vessels in the compact tissue. (3) But still further, even though the vascular connections are torn, and the periosteum be separated from the bone for an indefinite period, still the bone may not necrose, because the vessels in the compact tissue are still filled with blood on account of the anastomosis between the vessels of the marrow and the "endosteum" with those in the compact tissue from the periosteum. (4) The question, too, of septicity has a very important bearing on this point; even though the periosteum be extensively stripped up, if the wound be kept free from septic micro-organisms it will very likely unite again without a trace of necrosis, but this cannot possibly occur should the wound be septic.

3. The so-called "**nutrient artery**" passes into the interior of the bone and supplies the marrow and endosteum; it would be better therefore to call it the *medullary artery*. It reaches the interior through a distinct bony canal which runs obliquely through the shaft, near its middle; in the bones of the upper extremity the nutrient arteries are directed or run *towards* the elbow, while in the lower extremity they run *from* the knee. Another curious point is, that in young bones the epiphyses of that end towards which the nutrient artery runs, are the last to *begin* to ossify, but are the *first to unite* after they have begun; the lower end of the fibula, however, is an exception to this rule. When the artery reaches the interior of the bone, it divides into ascending and descending branches, which, on the one hand, anastomose with the vessels from the periosteum, and on the other, with the articular vessels at the spongy ends, after the epiphyses have completely united.

The Growth of New Bone.—By means of experiments with madder, which, when mixed with the food of young animals, renders the bone produced during its administration of a deep red colour, it was shown by DUHAMEL, that a coloured *ring* was produced under the periosteum, a coloured layer under the epiphyseal cartilage, and coloured circles in the Haversian canals; at these points, therefore, new bone is laid down. SYME, in 1840, showed that if a silver plate be inserted between the periosteum and the

bone, that the periosteum produced a layer of bone *outside* the plate, and further, proved that a bone may be regenerated after its removal, provided the periosteum be left. OLLIER, further, in 1867, showed that the periosteum produces bone, even when it is excised and planted beneath the skin. The sources of bone regeneration in disease or fracture are—(1) The osteoblasts of the deep layer of the periosteum; (2) the bone itself, probably from the osteoblasts contained in the Haversian canals, which sprout forth in the form of bone-producing granulations; (3) the soft tissues near the periosteum, as tendons and interosseous membranes and fascia; and, (4) doubtfully, the endosteum.

Re-absorption of Bone.—HOWSHIP was the first to observe small pits on the fangs of the milk teeth during their absorption, and also on the surface and interior of any bone undergoing absorption; these little spaces have been called *Howship's foveolæ.* TOMES and DE MORGAN discovered cells lying in these foveolæ, and gave birth to the theory that these cells absorbed the underlying bone; the cells in question are multi-nucleated masses of protoplasm, and have been named *myeloplaxes*, by ROBIN, and *osteoclasts*, by KÖLLIKER. In the madder experiments, while a red layer is found under the osteoblasts, the bone, under the osteoclasts, is unstained, showing at least that they do not produce bone. But while the osteoclasts may be the cause of bone absorption in physiological processes, I very much doubt if they have much to do with it in pathological processes, as in rarefying ostitis or acute inflammation of bone; here the compact tissue becomes opened out and rendered spongy by absorption of the walls of the Haversian canals. Now, if one examines the contents of an inflamed Haversian canal, the cell elements are found to be increased, the vessels enlarged and tortuous; in fact we find granulation tissue—masses of indifferent cells round loops of blood-vessels. But the property of granulation tissue is to eat up everything in its neighbourhood, and hence it attacks the walls of the Haversian canals, eating them away and rendering the compact bone porous or cancellous. This is the essential process in rarefying ostitis, and it is also observed in the ends of a fractured bone previous to the laying down and organisation of callus. Now compare the different effects of inflammation on bone:—(1) If it is *very acute* the bone at once dies *en masse*

(*necrosis* = gangrene of the soft parts), because the extra blood demand cannot be supplied in time to keep the bone alive, as it takes a week or ten days before the compact tissue can be opened up sufficiently. (2) If it is not quite so acute the bone becomes rarefied. (3) If at this stage, instead of beginning to subside, the inflammation continues, the bone becomes so rarefied that the trabeculæ give way and now we have the condition of *caries* (= ulceration of the soft parts, which is in turn = suppuration on a *free* surface), the broken trabeculæ flow away with the degenerated cells, and tissue remains (= *pus*). Hence it is that the pus in this case feels *gritty*, and so also when a probe is passed it enters soft, spongy, and very sensitive bone. This same series of changes also occurs in the formation of the "line of demarcation," which cuts off a dead mass of bone from the living, in cases of necrosis. (4) But suppose the inflammation is *chronic*, what takes place? The bone becomes *sclerosed*, the Haversian canals are filled up, and the whole bone may become hard and heavy as ivory; witness, for example, the hard polished articular ends of bones in chronic rheumatic arthritis, and the nodes on the surface of the tibia in syphilis, due to the localised chronic periostitis so common in the later stages of that disease.

FRACTURE IN GENERAL.

Fractures may be divided into *Simple*, *Compound*, and *Complicated*. 1. A **Simple Fracture** is one where the bone is merely broken across, split, or fissured, but where there is no wound of the soft parts communicating with the broken bones, nor yet near the injured point. 2. A **Compound Fracture** is one where the bone is not only broken, but the soft parts are torn through, so that the fracture communicates by a wound with the surface of the body, either through the skin or through the mucous membrane, as in the case of the lower jaw. The wound in the soft parts may be caused in two ways:—(*a*) By the *sharp end of the broken bone* being forced through the skin, as in fractures caused by indirect violence—*e.g.*, fracture of the tibia by a twist; (*b*) by *the injury* that breaks the bone, as in the different forms of direct violence. 3. A **Complicated Fracture**, when with the fracture is conjoined some other condition or injury which has no immediate connection with the fractured

point—*e.g.*, fracture of the tibia with a wound of the calf, fracture of the pelvis with rupture of the urethra, fracture of a rib with injury of the pleura or lung; also where the fracture is associated with injury of a neighbouring nerve, artery, or joint. As regards the *direction* of the fracture, it may be transverse, as from direct violence; oblique, longitudinal, or spiral, from indirect violence, as from sudden twists; *comminuted*, when it is broken into a number of fragments at one place. An **Incomplete** or **Green-stick Fracture** is when the bone is merely bent, with a crack extending across the convexity of the curve, similar to that produced in a green stick when it is bent across the knee. It usually occurs in children, and especially in the fore-arm and clavicle, and, in many cases at least, the periosteum is not torn; the bone is bent, but there is neither mobility nor crepitus. It must be distinguished from the curve of a rickety bone, which, however, is a chronic thing, not produced suddenly, is symmetrical, and not accompanied with marked pain. It is possible, of course, to get a green-stick fracture in a rickety child. An **Impacted Fracture** is where one fragment is wedged into the other, the compact tissue being driven into the cancellous; in this condition there is an alteration in contour and length, but neither mobility nor crepitus. It is usually met with at the lower end of the radius (COLLES's), and at the upper end of the femur. It is distinguished from green-stick fracture by the age of the patient, and the fact that the fractured point is angled, and not a rounded curve. A **Multiple Fracture** is where there are two or more fractures, either in different bones or in different parts of the same bone, as at the lower end of the humerus and femur, or both wrists (double COLLES). A **Diastasis** is the separation of an epiphysis; it is met with in persons under sixteen or twenty years of age, and, of course, occurs at the ends of bones near the joints, and is often difficult to diagnose. It is usually seen at the lower end of the radius or femur, and at both ends of the humerus. This is usually followed by a certain amount of shortening of the limb, as the life history of the epiphysis is suddenly hurried on to completion; it does not entirely stop growing at this end, however, as the attachment of the epiphysis to the shaft may be left undisturbed. In cases where there are two bones, the after effects are well marked —*e.g.*, after separation of the radial epiphysis the hand tends to grow

towards the radial side, as the ulna, growing faster than the radius, pushes it over; or, if the ulnar one be affected, the hand will be pushed to the ulnar side. Epiphyseal injury may be produced in three ways:—(1) From actual separation of the epiphysis; (2) from tubercular ostitis near the growing line; and (3) from a blow or fall jarring it, even though the injury be too slight to cause separation, yet an inflammation, it may be of a simple nature, is set up which causes premature ossification of the growing line.

The **Causes of Fracture** are either predisposing or exciting:— 1. The **exciting** causes are—(*a*) Direct violence, when the bone gives way at the point struck, and usually in a transverse direction; (*b*) indirect violence, such as a strain, when the bone gives way at the weakest part, and not where the force is applied; and (*c*) muscular action, as in the patella. 2. The **predisposing** causes are very various—as exposed position, age, sex, season of the year, tumours, and bone diseases, as gummata, sarcomata, etc.

The **General Signs** of fracture are—1. Alteration in the normal outline of the limb: this may arise from three causes—(*a*) The force which broke the bone, as the chief cause; (*b*) muscular action, as a secondary cause; and (*c*) the weight of the part. All these causes are illustrated very well in POTT's fracture. 2. Mobility in the continuity of the bone. 3. Crepitus or grating between the broken ends. Of course, other signs, such as swelling, pain, shock, etc., might be added to this list. In examining a limb for a supposed fracture, remember that the very last thing the Surgeon is to do is to handle the parts: learn everything else before touching, so as to give the patient as little pain as possible, and remember always to compare with the sound limb. He is first to look at it well, then compare it with its fellow, then measure; next gently run the fingers along the most prominent surface or edge; and lastly, if necessary, try for mobility and crepitus. As a rule, the presence of a fracture should be diagnosed without crepitus; for just as the last part of the Surgeon's examination is to handle the limb, so the very last part of handling should be the attempt to elicit crepitus. All the signs of fracture enumerated above may be due to other causes, except mobility in the continuity of the bone, *e.g.*, deformity may be due to a previous injury, crepitation, to the movement of tendons in their sheath, from lymphy exudation, and fluid in the

cellular tissue. Further, deformity may be absent in transverse fracture, and in cases where there are two bones side by side and only one is broken. Crepitus is absent in impacted and green-stick fractures, and obscure in diastasis.

The **indications for Treatment** are—1. To remedy the distortion as completely and as gently as possible; this is the most important part of the whole treatment. 2. To keep the fractured ends steady and in good position by the use of means that will command the joint above and below the fracture; in most cases, however, this will *not* be enough, notably in the case of the humerus, where the muscles that move the wrist and fingers take their origin from the lower end of that bone, and it is necessary, therefore, to command all the muscles, from origin to insertion, that are in any way attached to the broken bone, in order to avoid the risk of non-union. 3. In special cases, where the fracture is near a joint and surrounded by *tendons*, great care must be taken by judiciously early passive movement to avoid adhesion and stiffening of the tendons—*e.g.*, in COLLES's fracture of the wrist and in POTT's fracture of the ankle. This is specially important also in fractures near the elbow in young persons, with or without separation of the epiphysis, lest new bone be thrown out and render the joint stiff. In every case the splints ought to be looked to on the *second day*, lest the blood extravasation and serous oozing cause so much swelling of the limb that the splints become too tight and produce gangrene.

CHAPTER XXIV.

FRACTURES OF THE UPPER EXTREMITY.

THE CLAVICLE.

Development.—The clavicle is developed from two centres—one for the shaft which appears very early (before any other centre, it is said); so early does the ossification begin and so rapidly does it proceed that the whole shaft is bony at birth. The other centre is for the sternal end, and appears from eighteen to twenty years, and joins the shaft about twenty-five.

The clavicle is subcutaneous, and any irregularity therefore, as in the case of fracture with displacement, is readily felt. It is more frequently broken than any other single bone in the body, although the radius almost runs it neck to neck, and it is more frequently the seat of *green-stick fracture* than any other bone. Statistics show that one-half the total number of fractures of this bone occur before the age of five years. Green-stick fracture is very often subperiosteal in children on account of the very thick and strong periosteum that covers the bone; it is important to keep this fact in mind, as there may be little or no displacement, and the incautious practitioner may state to the parents that there is no fracture. In a few days "callus" is thrown out, forming a lump round the bone and leaving no doubt as to the nature of the accident. Should the case *then* fall into the hands of an unscrupulous brother practitioner, qualified or otherwise, the first is very likely to be severely blamed and probably lose his patient as well. Therefore be cautious, and take care to explain well to the parents the probable or possible result. It is also well in all cases where a child has had a fall, and continues crying, for no apparent reason, to examine the clavicle. Fracture of this bone

is very common, because—(1) It is much exposed to *direct* violence; (2) it is the only osseous connection of the upper extremity with the trunk. Its shape enables it to withstand, to a certain extent, *indirect* violence, the force being partially broken at each curve.

Causes.—(1) *Direct Violence*—Fracture from this cause happens comparatively seldom; when it does take place, the fracture is transverse and at the point struck. (2) *Indirect Violence*—This is the usual cause, as in falls on the shoulder, elbow, or hand; the direction of the fracture is oblique from without inwards and from before backwards, and as a rule is situated where the two curves meet, at the junction of the middle and outer thirds of the bone, as at this point the bone is more slender than elsewhere. In children and infants the usual cause is falling out of bed, or being dropped by a careless nurse. (3) *Muscular Action* has been known to break the bone, as in using a whip; in this case the fracture is usually on the right side and about the middle of the bone.

FRACTURES OF THE CLAVICLE.

1. Fracture at the **Sternal End.**—Fracture at the sternal end takes place about three-quarters of an inch from the end of the bone, internal to the rhomboid ligament, and is usually transverse. This may resemble a dislocation. The outer fragment is drawn inwards towards the sternum by the subclavius, and the pectoralis major and minor muscles. The inner end of the outer fragment is displaced downwards and inwards and can be felt moving on the front of the sternum.

2. At the **Junction of the Two Curves.**—This is by far the most common seat of fracture. The *outer* fragment is drawn downwards, forwards, and inwards—*downwards*, by the weight of the arm and scapula, and the action of the deltoid and other muscles acting on the scapula, as the pectorals and latissimus dorsi; *forwards*, by the pectorals and serratus magnus rotating it; and *inwards*, by the pectoralis major and minor, subclavius and trapezius, and muscles attached to the posterior border of the scapula—levator anguli scapulæ, and the rhomboids, major and minor, also the latissimus dorsi. At the same time the outer end is rotated forwards, whilst the inner end points backwards.

The *inner* fragment seems raised, but this is because the outer one is depressed; it is practically kept in its natural position by the sterno-mastoid above, and the pectoralis major, subclavius, and the rhomboid ligament below. In this fracture the patient cannot raise his hand to his head; he keeps the injured arm semiflexed, and supports it with his other hand, and leans his head and body to that side to relax the muscles. The slightest movement of the shoulder causes intense pain. The **special features** of this fracture then are—(1) Apparent projection of the outer end of the inner fragment, (2) depression of the outer fragment, (3) falling down of the arm, (4) narrowing of the chest, and (5) intense pain on the slightest movement of the injured shoulder.

3. At the **Coraco-Clavicular Ligament.**—If the fracture takes place between the conoid and trapezoid ligaments, there will be little, if any, displacement. This fracture is often caused by direct violence, and it comes to be a question of diagnosis of this fracture from a mere *bruise* of the periosteum. In a *bruise* the pain is *diffused* and dull, there being no specially tender spot, and no sign on indirect pressure. In fracture the pain is severe and strictly localised to *one spot*, which can readily be detected by carrying the finger along the bone from the sternal side; the *tender spot* is situated about the deepest part of the anterior concavity, immediately above the coracoid process. Further, there will be pain at this spot when firm pressure is made on the great curvature of the bone, at some distance to the inner side of the injured point, as the pressure makes the broken ends rub against each other (the *indirect method*). In a bruise, as the bone is not broken, there is no pain on applying this test. It may be possible to elicit crepitus on moving the shoulder.

4. It may be broken to the **outer side of the Coraco-Clavicular Ligament**, when the small fragment is gradually drawn round by the pectoralis minor and major, and serratus magnus, these muscles depressing and rotating forwards the point of the shoulder, until the broken fragment lies at right angles to the rest of the bone. By this means the shoulder is narrowed, and may drop a little from the weight of the arm; but, as a rule, there is little, if any, downward displacement of the outer fragment, as it cannot fall without the scapula moving with it; but the scapula is slung up by the

coraco-clavicular ligament, and therefore cannot fall down. This fracture is usually caused by direct violence. *Comminuted* fracture of the clavicle is dangerous because of its close relation to important vessels and nerves. The structures most likely to be wounded in fracture are the veins and the cords going to form the brachial plexus. The late Sir ROBERT PEEL in this way got a diffused false venous aneurism from a fall from his horse in Hyde Park, which was ultimately fatal. Accidents of this kind are, however, fortunately rare, probably on account of the dense fascia which underlies the clavicle, and the subclavius muscle, protecting the vessels from injury.

TREATMENT OF FRACTURED CLAVICLE.

The most certain method to secure union without deformity, is to keep the patient flat on his back in bed with a small pillow between the shoulders, for about three weeks, till the fracture unites; the head is placed on a thin pillow, and the arm bound to the side, with the fore-arm across the trunk. In this position the blade of the scapula is pressed close against the ribs, and in this way its outer angle, with the humerus and acromion process, is pulled outwards and backwards, and the recumbent posture removes the weight of the arm, which is the chief cause of the downward displacement. This plan may therefore be adopted in cases where it is specially desirable to avoid deformity, *e.g.*, in the case of young ladies. This plan *must* be adopted also in complicated and comminuted fractures, and in cases where both clavicles are broken at once.

I. For Fractures **internal to the Coraco-Clavicular Ligament.**—Whatever plan is adopted it must fulfil three conditions; as to the exact method there are no hard and fast rules, provided the deformity is remedied. The conditions are that the shoulder must be drawn—(1) outwards, (2) upwards, and (3) backwards.

1. The shoulder may be drawn *backwards* by a figure-of-eight bandage round the shoulders and stitched behind. But this is objected to, because the front turns of the bandage may press on and displace the inner end of the outer fragment.

2. The *inward* displacement may be overcome by an axillary pad, which acts as a fulcrum to the upper end of the humerus,

the shoulder being carried outwards when the elbow is pressed to the side. This also is objectionable, because of the compression it exerts on the axillary vessels and nerves, causing great pain and œdema at first, and probably paralysis afterwards.

3. The *downward* displacement is best counteracted by raising the elbow. The arm is firmly fixed to the side by a broad domett bandage, so guided that it will also support the elbow of the injured side. Or a special sling may be used.

(*a*) **By Three Handkerchiefs.**—1. One, folded diagonally, is rolled round a pad of wool, and the pad is placed in the axilla of the injured side, the ends being crossed on the top of the opposite shoulder over a small pad, and thence under the axilla, which is also padded, and the ends tied in front over a small pad of wool. 2. The second, also folded diagonally, is applied as a sling over the opposite shoulder to support the *elbow*, and the base of the triangle is therefore applied to this point; the fore-arm is flexed at an acute angle and laid so that the fingers almost touch the shoulder of the opposite side. 3. The third, is applied round the trunk and elbow, so as to fix the arm to the side.

In order to get rid of the axillary pad we may adopt VELPEAU's plan—viz., to carry the elbow of the injured side well across the chest, pushing it upwards at the same time, so that the hand rests on the opposite shoulder, and fixing it there by bandages in the same way that the arm is fixed up in cases of excision of the breast. By this means the point of the shoulder is pushed directly backwards, upwards, and outwards—the side of the chest being the fulcrum, and the humerus the lever.

(*b*) **Sayre's Method.**—Two pieces of adhesive plaster spread upon strong calico or moleskin, about three and a half inches wide, or less, according to the size of the patient, and for an adult, about two yards in length. On one of the pieces a loop is made and *stitched*, which is passed round the arm of the injured side about its middle third; the loop must be quite loose, so as not to compress the vessels, and the non-adhesive side of the plaster next the skin, so that the adhesive side of the rest of the plaster may be next the body. By means of this piece the arm is drawn well *backwards*, and then the plaster is carried round the body one and a half times and the end stitched to the first turn. The second piece passes from

the sound shoulder obliquely round the chest, the injured arm being drawn well *forwards*, when the loop round the arm acts as a fulcrum, and the shoulder is thrown backwards and outwards; a slit is cut in this piece for the point of the elbow, which is at the same time pushed well upwards. The second piece is then fastened to itself over the sound shoulder; it must be long enough to complete this circumference once and leave about eight inches more. By these means the blade of the scapula is pressed close to the ribs, and in this way the point of the shoulder is thrown outwards and backwards. It is better, at the same time, to apply a domett bandage to fix the arm more securely to the side, and support and steady the elbow.

II. Fractures **at the Coraco-Clavicular Ligament.**—All that is required is simply a broad domett bandage to fix the arm to the side for a couple of weeks.

III. Fractures **External to the Coraco-Clavicular Ligament.**—In this case there are only two displacements to counteract, forwards and inwards; and for this purpose the shoulder must be braced back and the arm fixed to the side—(*a*) **By figure-of-eight bandage** round the shoulders and fastened behind. This counteracts both the inward and the forward displacements; or (*b*) **two padded handkerchiefs** may be used, carried round the axillæ from behind, over the tips of the shoulders, and tied or *stitched* at the back over a pad. The arm is then secured to the side as usual.

In adults, fractures internal and external to the coraco-clavicular ligament will unite in about *four* weeks; at the ligament, a rest of *two* weeks will be sufficient. Fractures of the clavicle in children will unite in *three* weeks, and in infants in *two* weeks.

FRACTURES OF THE SCAPULA.

Fractures of the **Body** of this bone are rare. When they occur all that is required is a thick, soft pad, and a broad bandage to steady the parts. The **Anatomical Neck**, that is, of the glenoid cavity, external to the root of the coracoid process. A fracture through the anatomical neck is usually caused by direct violence, and may simulate a subglenoid dislocation of the humerus; but by raising the arm the parts resume their natural appearance, with the production of crepitus probably, but become displaced again

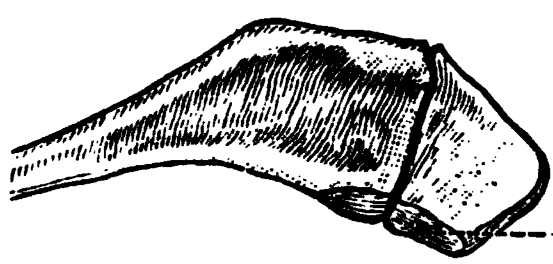
when the support is removed. The **Treatment** is to raise the elbow, place a pad in the axilla, and bind the arm to the side.

Fracture through the **Surgical Neck**, that is, of the glenoid cavity, and passing through the supra-scapular notch, and internal therefore to the root of the coracoid process. As the powerful coraco-clavicular ligament is not ruptured, there can be no displacement, as the broken fragment is slung to the clavicle; hence there will be crepitus, but no deformity. One can only diagnose this condition by a process of exclusion (CHIENE). All that is required in the way of **Treatment** is to place the fore-arm across the chest and bind the whole arm firmly to the side.

Fracture of the **Acromion Process.**—Many of the cases of supposed fracture of this process are believed to have been instances of non-union of its epiphyseal centres, which appear, one at fifteen,

Fig. 77.

EPIPHYSIS OF ACROMION PROCESS.



Unites from 22 to 25 years of age.

and the other at sixteen years, and unite sometime between twenty-two and twenty-five years of age (Fig. 77). The **cause** is usually direct violence, as a blow on the tip of the shoulder, or it may result from the head of the humerus being forced upwards from a fall on the elbow. It is necessarily associated with dislocation of the acromio-clavicular articulation. The broken fragment is drawn downwards by the deltoid, though the strong periosteum and the trapezius oppose the tendency to great deformity; the arm feels as if it were dropping off, and is, therefore, supported by the other hand. The patient can neither raise nor abduct the arm. As the bone is subcutaneous, by running the finger along the spine of the scapula, the fracture may be readily detected, and, by raising the arm, the deformity is removed, probably with the production of crepitus. The **Treatment** is to support the elbow in a sling and fix the arm to the side.

Fracture of the **Coracoid Process.**—Fracture of this process is rare, because of its depth, and because it is so well protected by neighbouring bones. Occasionally, however, fracture is produced by direct violence, though Mr LANE believes that it is usually broken by *indirect* violence, as a fall with the arm fully flexed at the shoulder joint, so that the coracoid process is jammed against the under surface of the clavicle; the same thing would also take place when a person falls from a height and catches hold of some thing with his hands—the sudden check would jam the process against the clavicle. This injury is often associated with dislocation of the shoulder. Like the previous process, it may be merely the separation of an epiphysis; a centre appears during the first year near the tip of the bone, and unites with the rest from twenty-two to twenty-five years of age. If the fracture is external to the coraco-clavicular ligament, the detached fragment will be displaced downwards and inwards by the short head of the biceps and coraco-brachialis on the one hand, and the pectoralis minor on the other. If internal to the ligament, there will be no displacement, as it will simply be slung up to the clavicle by the strong coraco-clavicular ligament. The **Treatment** will be to bend the arm to an acute angle, to relax the biceps, support the elbow, and bind the whole arm to the trunk.

THE HUMERUS.

This bone is **developed** by seven centres; that for (1) the shaft appears about the fifth week of fœtal life, and at birth the shaft is pretty well ossified though the ends are cartilaginous. (2) A centre for the head appears during the first or second years, and unites with the tuberosities in the line of the anatomical neck, about the age of five (Fig. 78). Before five years of age, therefore, it will be possible to have a separation of this epiphysis. (3) There is a centre for the tuberosities which appears during the second or third years, and after being joined by the head of the bone, unites with the shaft at twenty years of age (Fig. 79), the line of union being considerably above the surgical neck, so that from five to twenty years of age we are more likely to have a separation at this line than fracture of the surgical neck (Fig. 78). The length of the bone is mainly due to growth from this upper epiphysis. At the lower end there are

Fig. 78.

Upper End of Humerus.

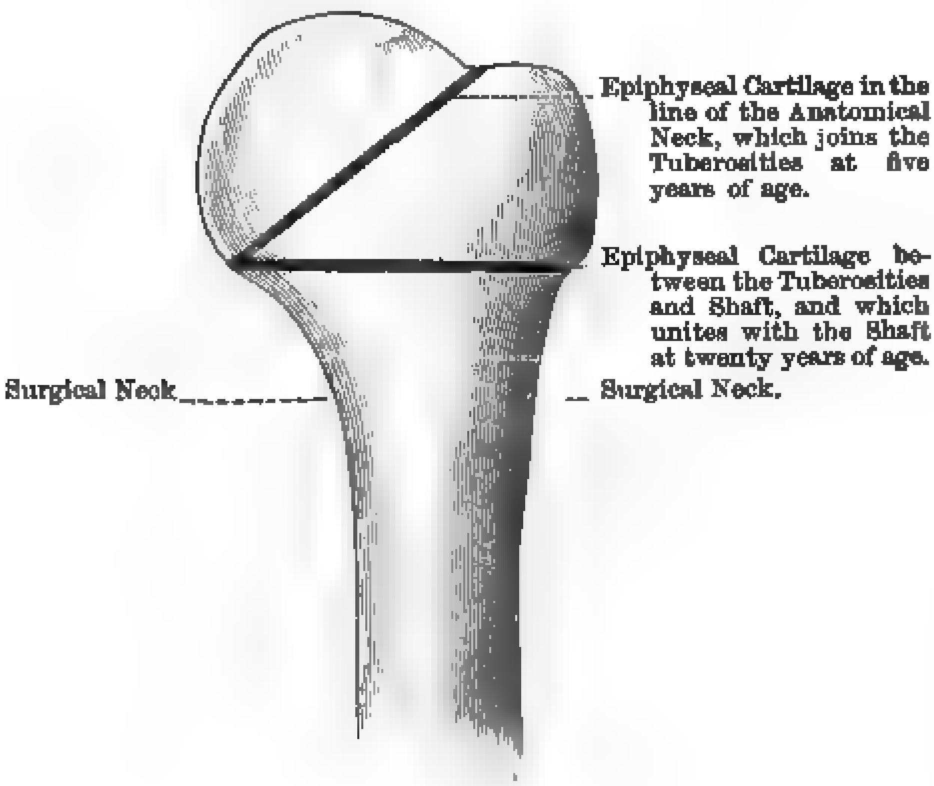
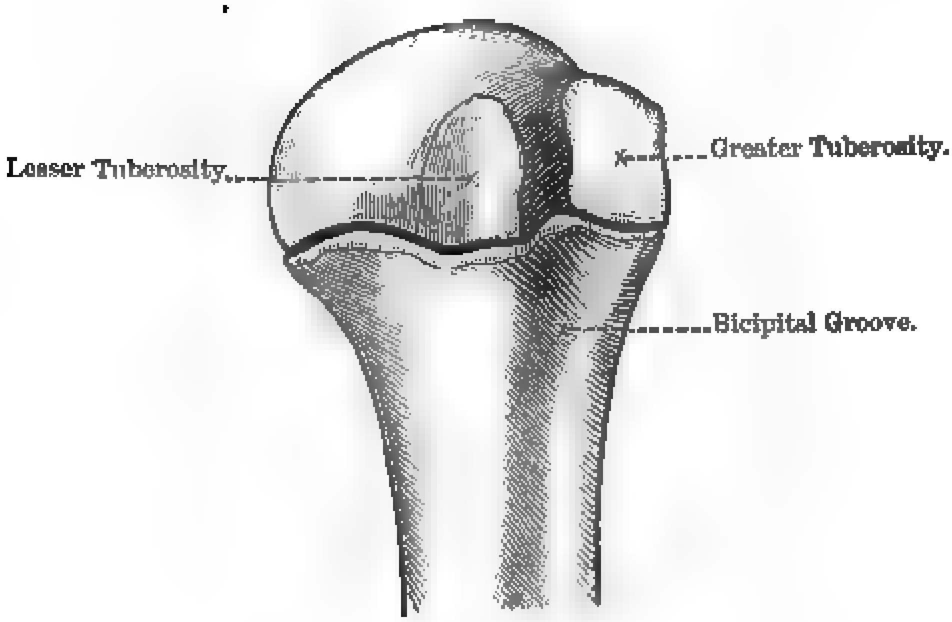


Fig. 79.

Upper End of Humerus.

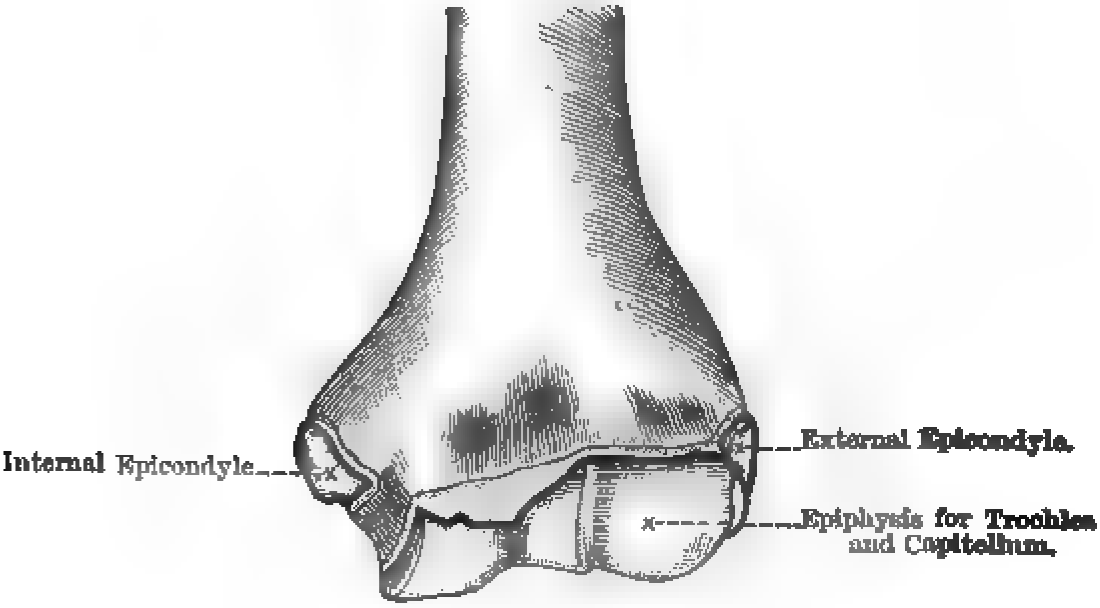


Unites at 20 years of age.

other four centres appearing at various ages, and all, save that for the internal condyle, unite with the shaft at sixteen or seventeen years of age. That for the internal condyle is the last to unite, union taking place a year or so later—at eighteen years (Fig. 80).

Fig. 80.

Lower End of Humerus.



Complete union at 18 years of age.

The humerus is most thickly covered by muscles on its anterior and posterior aspects, and fractures are best detected by running the fingers and thumb along the *sides* of the bone. The shaft is very often the seat of ununited fracture; this was well seen in the case of the late Dr David Livingstone, the African Missionary and Explorer, about the middle of whose left humerus a pretty complete false joint had formed. The cause of non-union of the humerus is doubtful, but it is probably to a great extent due to imperfect fixing of the joints above and below the fracture, and of the muscles that act on the wrist and fingers. Some say it is because the elbow is usually left unsupported during the after treatment of the case; and others, that it is due to the inclusion of some muscular tissue between the broken ends, which is very likely to happen since the bone is so closely enveloped by muscles —the brachialis anticus in front and the triceps behind—and

especially where the fracture is caused by direct violence, for then the tissue is directly driven in between the broken ends. The causes of these fractures are—(1) *Direct Violence*, the usual cause of fractures at the upper end; (2) *Indirect Violence*, as falls on the hand or elbow; and (3) *Muscular Action*—the humerus is said to be more frequently fractured from this cause than any other bone in the body. It is usually the shaft that is thus broken, as in throwing a ball or striking a blow straight from the shoulder, when the humerus gives, either from the actual force of the blow or else from the object having "dodged" it.

Anatomical Neck.—Fractures of the anatomical neck may be impacted or non-impacted. In the first case the head of the bone is driven into the cancellous tissue of the upper end of the humerus; in the non-impacted the head lies loose, like a foreign body in the joint, and will almost certainly necrose, a condition far less favourable to union than the impacted variety. Before five years of age it is merely a separation of the head at the epiphyseal line. Fractures of the anatomical neck are mostly caused by severe direct violence, as falls or blows on the shoulder, usually in old people. The exact way in which this occurs is doubtful, but Dr CAIRD has pointed out that there is probably a partial dislocation in the first instance, and the anatomical neck is then jammed against the sharp anterior edge of the glenoid cavity which splits it off. The signs are not very definite: by the finger in the axilla the surgical neck can be felt entire, but still crepitus is elicited on moving the shaft of the humerus, and it may be possible to feel the detached head. It is often partly extra-capsular at the upper part, running obliquely through the greater tuberosity; under these circumstances there will probably be some broadening of this tuberosity, as the upper fragment is driven into it. There is further, pain, slight flattening of the shoulder, loss of movement, and probably slight shortening. Observe that in impacted intra-capsular fracture the upper fragment is driven into the lower; in extra-capsular, the lower is driven into the upper. In fractures of the upper end of the femur the reverse obtains.

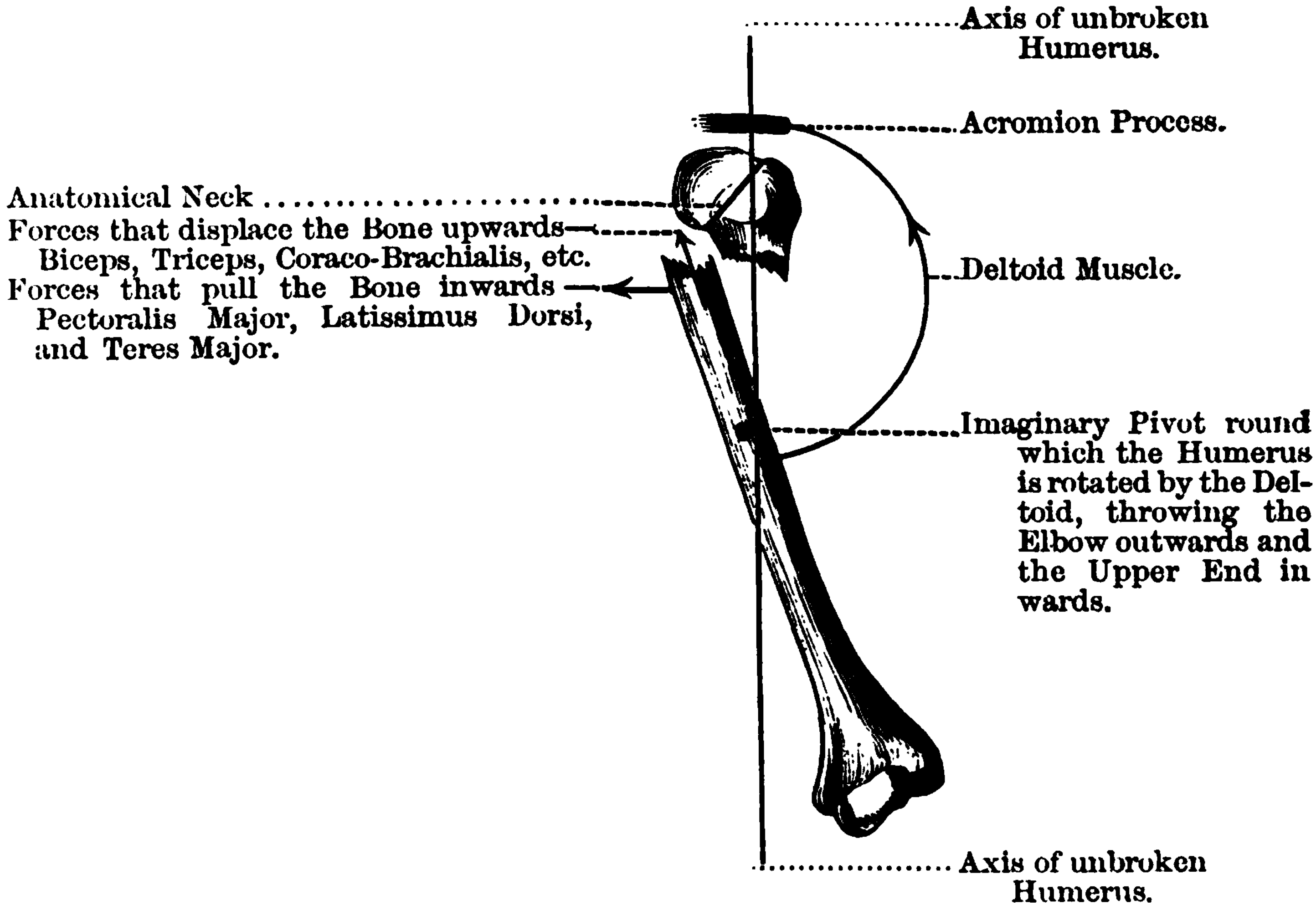
Fracture of the Surgical Neck, that is, below the great tuberosity, but above the muscles inserted into the bicipital groove. It may be impacted or non-impacted; it is the most frequent fracture

in this region, and is usually transverse in direction. It is usually caused by direct violence, as severe falls or blows on the shoulder, in elderly people. As already stated, separation at the epiphyseal line between the tuberosities and the shaft can only occur before the age of twenty. This line does not correspond to the surgical neck, but is considerably above it. In this case the upper fragment of the bone remains in the glenoid cavity, while the upper end of the lower fragment is drawn inwards and upwards, and forms a marked projection just beneath the coracoid process, rounded and smooth in outline, and when crepitus can be detected it is softer in character than ordinary crepitus; the upper fragment (the epiphysis) is held in position by the muscles attached to the tuberosities, which are inserted above this epiphyseal line. Fracture proper through the surgical neck is recognised by the shortening, crepitus, distortion, the axis of the bone being directed downwards and outwards, and loss of power of the arm, while the shoulder is rounded and swollen. The shaft of the bone moves independently of the head when the elbow is rotated, and by pushing the fingers up into the axilla the upper end of the lower fragment may be detected. The elbow can be brought to the side while the hand is placed on the opposite shoulder. The upper end of the lower fragment can be felt under the coracoid process, especially when the elbow is pushed up and rotated. The *upper* fragment, together with the head of the bone, is rotated outwards, abducted, and raised by the muscles attached to the greater and lesser tuberosities—supra-spinatus and infra-spinatus, teres minor, and subscapularis; still, the displacement is not great, because the muscles of the two tuberosities almost counterbalance each other. The only muscle not balanced is the supra-spinatus, which may, therefore, and sometimes does, cause persistent abduction of the fragment. The *lower* fragment is drawn upwards, inwards, and forwards—upwards by the biceps, triceps, and deltoid; inwards and forwards by the pectoralis major, latissimus dorsi, and teres major. The axis of this part also is altered, the elbow being tilted outwards by the action of the deltoid (Fig. 81). At first sight this injury may seem to resemble subglenoid dislocation of the head of the humerus; but the head of the bone can be felt in its natural position, the limb is *shortened*, and there is increased

mobility, and we may easily elicit crepitus. Further, the depression in fracture is not immediately under the acromion process, as in dislocation, but at some distance below this point—below the lower end of the upper fragment, a little above the insertion of the deltoid. In *impacted* fracture there is no mobility, displacement, nor crepitus. In this case the lower fragment usually penetrates into the cancellous tissue of the superior—the reverse of impacted fracture of the anatomical neck. The signs of this condition are obscure, and chiefly of a negative character.

Fig. 81.

FRACTURE THROUGH SURGICAL NECK.



Treatment of fractures and diastasis of the necks of the humerus—(1) "Set" the bones by extension; (2) place a pad in the axilla to keep the upper end of the lower fragment outwards; (3) bend the elbow to a right angle, and keep the upper arm parallel with the side of the chest, and rather in advance of the mid-axillary line, so as to counteract the forward displacement of the upper end of the lower fragment; (4) use a sling to support the *hand* only, so that the weight of the limb may overcome the

upward displacement. The late Professor SPENCE taught that the *elbow should be supported*, so as to keep the ends of the bone in apposition, and secure firm union; (5) the arm must then be firmly bandaged to the trunk by a broad domett bandage, but must not be carried across the chest, as in fracture of the clavicle, as this would bend the bone at the seat of fracture, and cause angling. Some advise that the hand and fore-arm should be bandaged lightly so as to avoid venous congestion, but this is unnecessary, and may even be injurious. No splints are required, but if necessary a gutta-percha cap may be moulded over the shoulder and upper part of the humerus, to steady the parts, especially in the case of children or restless patients; or the cap may be made of moulded "poroplastic" material, with a rectangular splint attached, of the same material, to pass along the outer side of the arm and fore-arm to the tips of the fingers; this will insure perfect rest to the injured bone. Splints are of no use as regards co-aptation of the fragments, for it is impossible to put the internal splint so high as the fracture, and one splint alone is useless. In cases where the upper fragment is persistently abducted, and it is consequently impossible to bring it into line with the lower, the lower fragment must then be abducted, to bring it into line with the upper, some such means as "Middledorpf's triangle" being used for this purpose. The fracture unites in from four to five weeks in youth, but requires longer in old age—two to five months.

THE GREAT TUBEROSITY.

Separation of the Great Tuberosity.—This may be caused by falls or blows on the shoulder, or from powerful contraction of the muscles inserted into it; it may also accompany dislocation of the shoulder. The separated fragment is carried outwards and upwards by the three muscles attached to it—supra-spinatus, infra-spinatus, and teres minor; while the other part of the head with the shaft of the bone is drawn upwards and inwards by the muscles passing from the trunk and scapula to the arm—subscapularis, pectoralis major, latissimus dorsi, and teres major—as well as the flexors and extensors—triceps, biceps, and coraco-brachialis. There is flattening and great widening of the shoulder, with a double projection

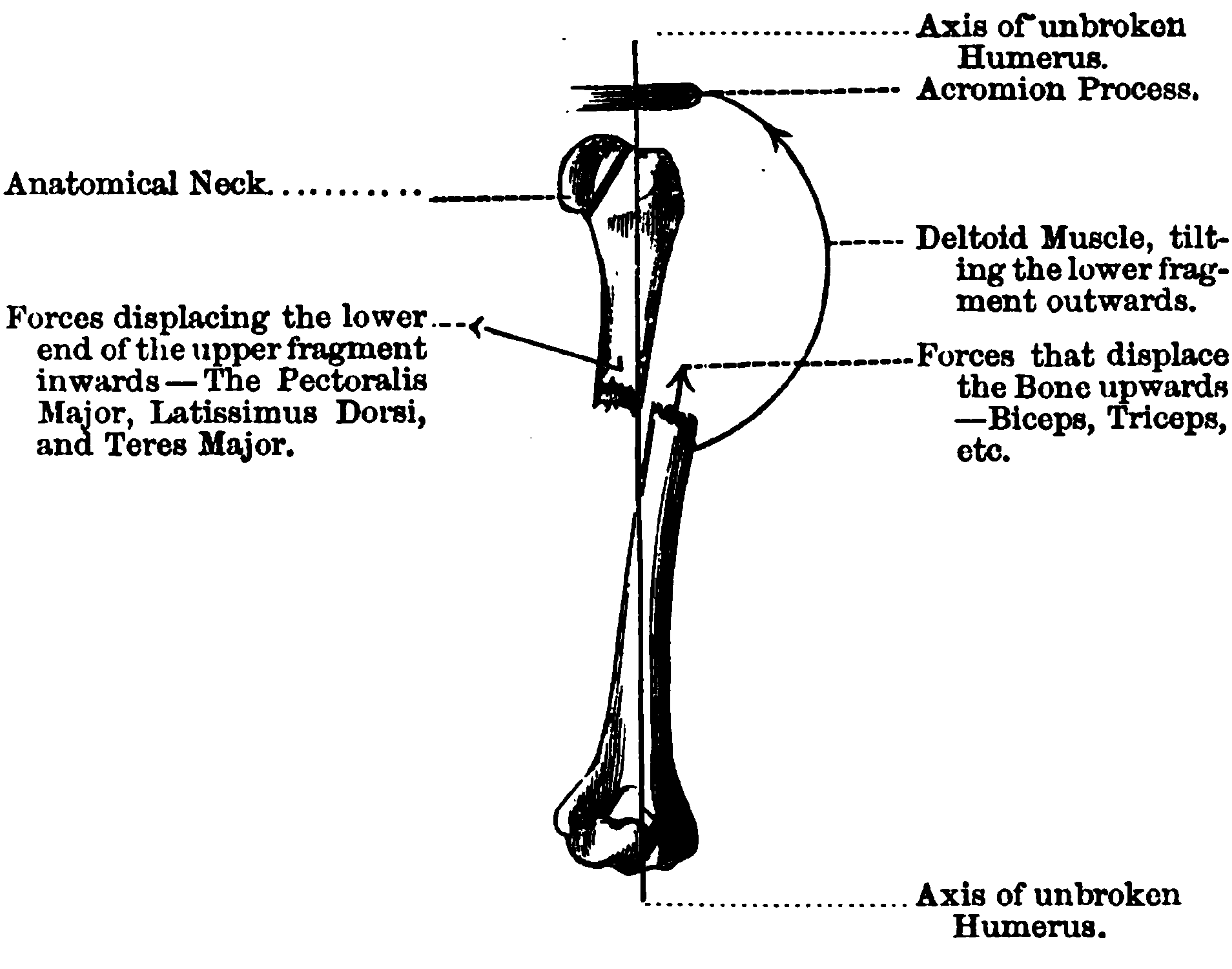
and a groove between. The anterior projection rotates with the shaft of the humerus, but the posterior projection does not. The **Treatment** is to pad the axilla, to throw the anterior fragment into its proper place, and then, by a compress behind, the detached fragment is pressed into apposition ; or the patient may be kept in bed, and the muscles displacing the parts relaxed by raising and abducting the arm.

SHAFT OF HUMERUS.

Fractures of the **shaft** of the humerus are usually transverse, but may be oblique from above, downwards, and outwards, when the brachialis anticus and biceps muscles in front, and the triceps behind, will cause a certain amount of displacement and shortening,

Fig. 82.

FRACTURE ABOVE THE DELTOID.



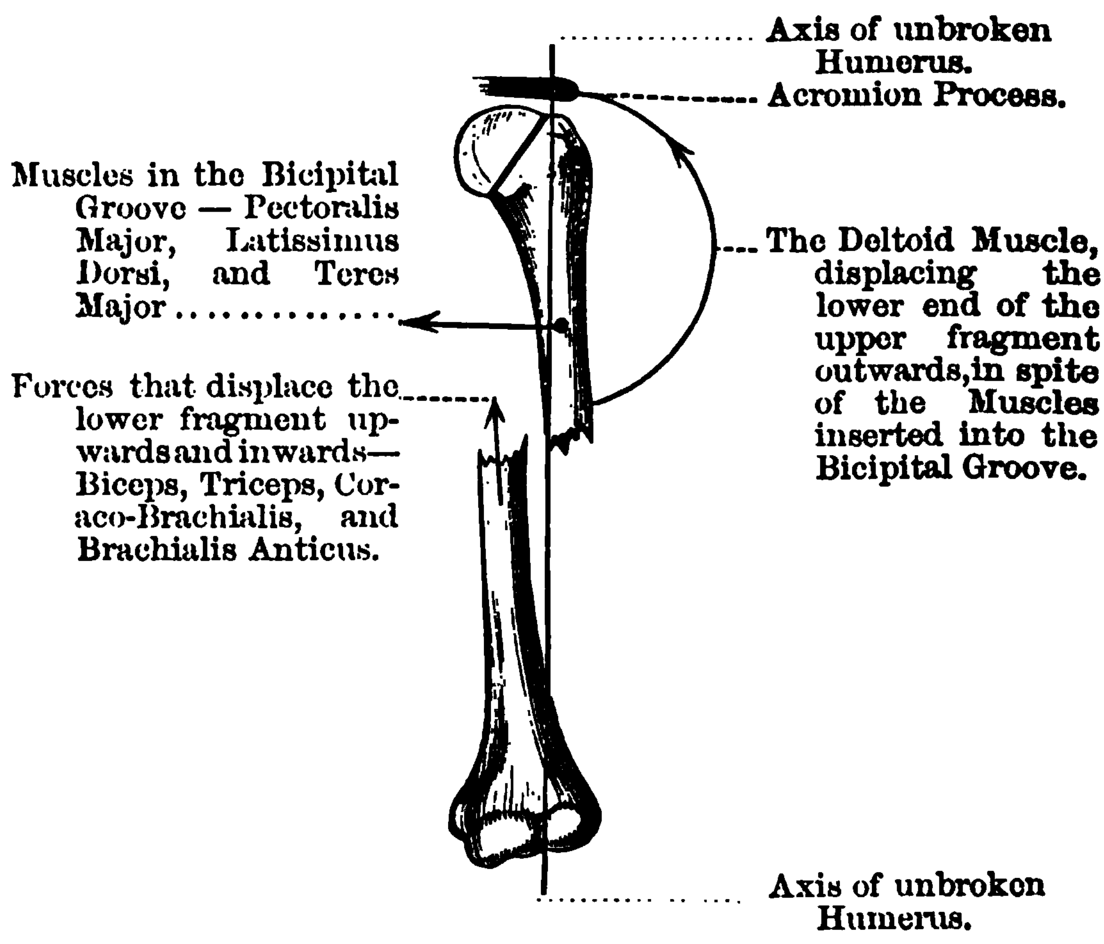
by making the parts glide over each other. The shortening, however, is not usually great, on account of the weight of the arm; the usual amount is about three-quarters of an inch. The usual **causes** are direct violence, indirect violence, as a fall on the elbow, or muscular action. If the fracture be transverse there may be

no displacement, only a slight angling. If fractured at a point between the insertion of the deltoid below, and the muscles in the bicipital groove above, the *lower* fragment will be drawn upwards by the deltoid, biceps, and triceps, and glide to the outer side of the *upper* fragment, which will be drawn towards the chest by the muscles in the bicipital groove—pectoralis major, latissimus dorsi, and teres major (Fig. 82).

Fracture below the Deltoid impression.—The upper fragment is abducted by the deltoid and supra-spinatus, while the lower

Fig. 83.

FRACTURE BELOW THE DELTOID.



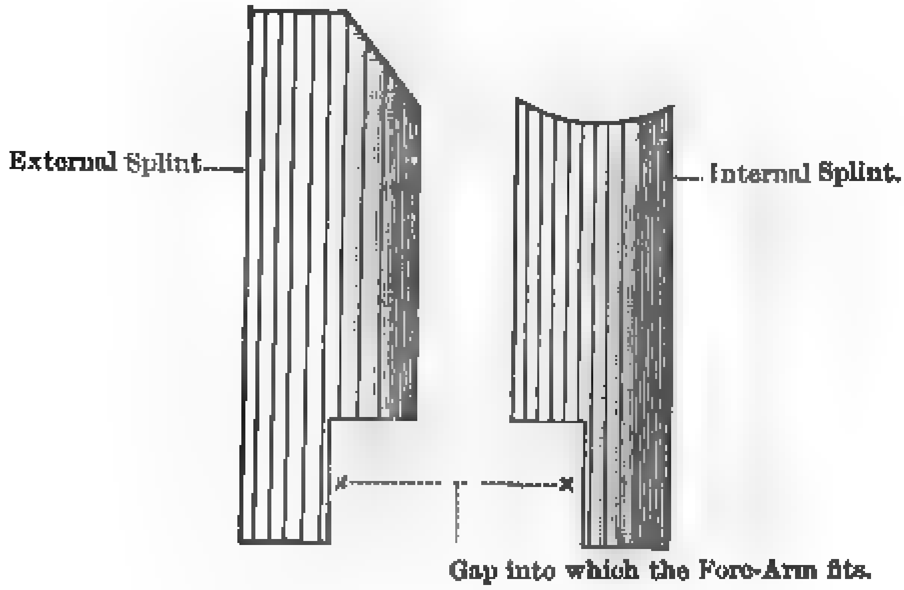
fragment is drawn upwards and to its inner side by the biceps and triceps (Fig. 83). *The* great sign of fracture of the shaft of the humerus is *mobility in the length of the bone*, as in all cases where there is but one bone in a limb, or if two, where both are broken: fix the upper fragment, and then try to move the elbow laterally.

Treatment of Fractures of the Shaft.—Two GOOCH splints, sufficiently broad to almost completely surround the arm when padded. From the upper and anterior angle of the outer one a

triangular piece should be cut off in order to allow the splint to be carried well up over the point of the shoulder, which could not be done were the upper end cut square, as the anterior corner would hitch against the anterior fold of the axilla. This external splint must be long enough to reach from the tip of the shoulder to the lower end of the elbow when the arm is bent; a rectangular slice must be cut out of its anterior inferior corner—*i.e.*, from its *inner* side. The inner is cut nearly square at the top, or slightly scooped out, but a like slice, to that cut from the outer splint, is

Fig. 84.

Splints for Fractured Humerus.



The student must carefully note that these two splints alone are *not* sufficient for fractures of the shaft of the Humerus. It is *absolutely necessary* to carry a splint from the shoulder to the *tips of the fingers.*

cut from its *outer* and lower corner (Fig. 84). Both splints are to be well padded, especially the upper end of the inner splint. The elbow is bent at a right angle, and the fore-arm fits into the gap at the lower ends of the two splints, to which it is fastened by a few figure-of-eight turns of bandage. The splint above this is to be fastened with slip-knots, the fore-arm slung, but the elbow left unsupported. Instead of using two splints of the same shape, the external one may be made like the above, and the internal simply a narrow, straight piece of board with a piece cut from its lower

end to avoid pressure on the internal condyle. The arm must not be put across the chest, as in fracture of the clavicle, as this would bend the bone at the seat of fracture.

It is important, however, in all cases to fix both the elbow and shoulder joints either by an external or internal rectangular splint or both, the external reaching to the *tips of the fingers*, to command the muscles acting on the wrist and fingers, since they mostly arise from the lower end of the humerus, and every time the fingers are moved the fractured point is disturbed. The neglect of this precaution very often leads to an ununited fracture. Should an internal one be used, care must be taken not to press unduly on the axillary vein, or the internal condyle; a hollow pad must be placed over the internal condyle, or else a hole cut out of the splint. If an external one be used, it must be carried from the acromion process to the finger tips, and its upper part expanded in order to envelope and steady the shoulder. It is most convenient to make the rectangular splints of poroplastic. In some books great stress is laid on the fact that the elbow is to be supported in cases of fracture of the shaft of the humerus, as otherwise, it is stated, non-union is apt to take place. But probably the real cause of non-union in most cases is, because the joint on each side of the fracture, as well as the fore-arm and fingers, have not been thoroughly kept at rest. Fractures of the shaft unite in from four to six weeks, according to the age of the patient.

FRACTURES NEAR THE ELBOW.

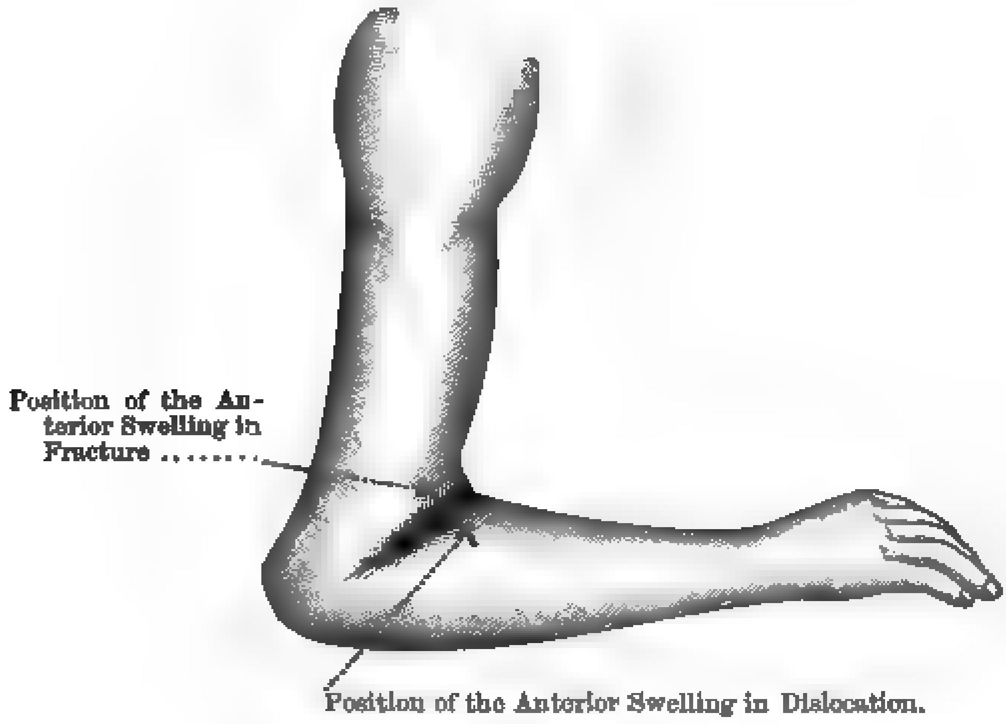
Fracture just above the Condyles.—This fracture occurs chiefly in young persons. The usual **cause** is a fall on the semi-flexed elbow. It may be confounded with **separation of the epiphysis** in children, or **dislocation of both bones of the fore-arm backwards**; but the presence of crepitus, the fact that the limb assumes its normal appearance on extension, but becomes distorted again when the extension is discontinued, the increased mobility, and the guide already mentioned—viz., the relation between the internal condyle of the humerus and the olecranon process—will aid the diagnosis, both in fracture and separation of the epiphysis. In separation of the epiphysis there is no crepitation, or, if there is, it is very soft in character. The deformity is easily reduced, but difficult to

retain, the bony points maintain their proper relationship, and the patient will probably be under sixteen years of age. The lower fragment is carried backwards and upwards behind the upper fragment by the triceps, biceps, and the brachialis anticus muscles, just as in fracture proper, but the anterior projection is broader and more rounded than in fracture.

In fracture, separation of the epiphysis, and dislocation of both bones backwards, the general appearance is the same (Fig. 85); but in fracture and separation of the epiphysis the bony points about

Fig. 85.

DISLOCATION OF BOTH BONES BACKWARDS.



the elbow joint are the same as on the uninjured side, which is not the case in dislocation. Since, however, the epiphyseal line is *wholly within the capsule*, the displacement is not likely to be great unless there be a partial fracture through the lower end of the humerus as well.

In **Fracture proper** the displacement is very similar to the above, the lower fragment is pulled upwards and backwards behind the upper, and carries the fore-arm with it; so that the olecran- projects unnaturally, and there is a hollow above it (Fig. 8

The lower end of the upper fragment is tilted forwards, forming a prominence in front, *above* the crease in front of the elbow joint (in dislocation of both bones backwards the prominence is *below* this crease). In fracture, also, the distance between the acromion process and the condyles is lessened, but not so in dislocation. So also the mobility, crepitus, and the fact that the deformity is easily reduced by extension, and the absence of any change in the relative positions of the various bony points around the joint, should prevent the student mistaking this accident for dislocation of both bones backwards. The fracture is transverse from side to side and oblique from behind downwards and forwards; the muscles displacing the lower fragment are the triceps, biceps, and brachialis anticus. The median and ulnar nerves are apt to be injured.

Treatment.—Set the bones by extension of the arm and fore-arm, and press the lower end of the humerus backwards and the lower fragment forwards, and then bend the elbow to an acute angle. In this way the triceps behind acts as a posterior splint, and keeps the lower fragment pressed forward; next, place a pad of cotton wool in the bend to exert counter-pressure, and keep the lower end of the upper fragment backward. The elbow is then to be bandaged by successive divergent figures-of-eight sufficient to secure it in this position, and the arm then carried in a sling midway between pronation and supination, or else bound firmly to the trunk. Begin gentle passive movement *early;* the seat of the fracture can be secured between the fingers and thumb of the one hand, while the other moves the fore-arm. Being near the spongy end of the bone there is but little danger of non-union.

Fractures of the Condyles.—Fractures of the condyles are usually caused by direct violence, such as falls or blows, or from muscular action. The inner one is more often fractured, and the detached piece (when the "epicondyle" alone is broken) is carried downwards and outwards by the muscles attached to it. The signs are pain, impairment of motion, mobility of the fragment, and crepitus. In cases where the articular surface is involved in fractures at the lower end of the humerus, they are almost always followed by some permanent damage to the joint, unless very great care be exercised in their diagnosis and after treatment. The joint may be involved by fracture of either condyle, or transverse fracture

of the lower end of the humerus, with a vertical fissure between the condyles running into the joint—the T-shaped fracture; in this case, it is said that the tip of the olecranon acts as a wedge, producing the transverse part of the fracture; while the ridge along the middle of the greater sigmoid cavity also acts as a wedge, and produces the vertical fracture into the joint. The various forms are usually produced by falls on the bent elbow. In fracture of the external condyle the fissure is usually situated between the capitellum and the trochlea; of the internal, it runs through the centre of the trochlea. In the T-shaped fracture the width between the condyles is increased, and by grasping the condyles each can be moved independently of the other with the production of crepitus. In fracture of the internal condyle into the joint, the fragment is dragged upwards and inwards, and carries the ulna with it, so that the relation between the internal condyle and the olecranon process is normal, but not so its relation to the external condyle; there is also a marked increase into the antero-posterior breadth of the condyle. This is very frequently associated with dislocation of the head of the radius backwards.

The different Fractures of the Lower End of the Humerus, then, are:—(1) An oblique fracture just above the condyles; (2) separation of the lower epiphysis; (3) a transverse fracture across the lower end of the humerus, with a vertical split into the joint—"the T-shaped fracture"; (4) fracture of the internal condyle, involving the joint; (5) fracture of the external condyle, involving the joint; and (6) up to eighteen years of age, separation of the internal "epicondyle," which is wholly extra-articular.

Treatment of Fractures of the Condyles.—As there is usually considerable swelling and inflammation of the joint, the ordinary means must be taken to allay the inflammation; after this get the bones into proper position by extension, counter-extension, and manipulation, and then put up the limb with the arm at right angles to the fore-arm and the hand midway between pronation and supination. For this purpose some use a jointed rectangular splint on the inner aspect of the fore-arm. But, probably, the best way is to apply two moulded poroplastic rectangular splints of such a size as almost to envelope the arm when padded, the posterior one reaching to the tips of the fingers. The arm is then supported

in a sling. Begin passive movement *very early*, within seven days (HAMILTON), in case the joint be stiffened either by fibrous adhesions, union of the detached parts in wrong positions, or else by the excessive production of callus adhering to the articular surfaces. Another way (which is suitable in *all* cases of injury about the elbow joint except fracture of the olecranon) is to bend the arm to an acute angle, place a pad in the bend, and retain it thus by a figure-of-eight bandage, and afterwards to sling or bind the arm to the side (SPENCE).

NERVE LESIONS.

Nerve Injuries following fractures of the humerus.—In fractures of the shaft of the humerus, the musculo-spiral nerve may be injured, either directly, at the time of the accident, or later, by the "ensheathing callus." Lower down, at the external condyle, the posterior interosseous branch alone may be injured. If the **trunk of the musculo-spiral** be injured, supination is imperfect, extension of the hand and fingers is entirely lost, and the hand becomes pronated, and "wrist drop," somewhat resembling that seen in lead palsy, ensues; extension of the elbow will probably be impaired, or altogether lost. As the biceps, however, is not paralysed, a certain amount of supination is still possible. Further, the *lumbricales* and the *interossei* are not paralysed, so that the upper two joints of the fingers, if forcibly bent, may be again extended, as these muscles are supplied by the median and the ulnar nerves, and their function is to flex the first phalanx and extend the other two; the fingers are flexed, and cover the thumb, which is also flexed and adducted. It is to be distinguished from lead-poisoning by the history of the case—occupation, blue line on gums (from the sulphide of lead), colic, trembling of the muscles previous to their actual paralysis, and by the early appearance and well-marked character of the "reaction of degeneration," as shown by the continuous current. In lead-poisoning too, curiously enough, the supinator longus muscle is not affected; this can readily be shown by placing the hand midway between pronation and supination, and pressing down the upper edge of the hand while the patient attempts to bend the elbow, when the muscle will be seen as a distinct resisting band. When the trunk of the musculo-spiral

is paralysed, as in "crutch palsy," in "Saturday night palsy," and by pressure of the axillary pad in cases of fracture of the clavicle, this muscle is paralysed to the same extent as the rest of the group. The "reaction of degeneration," and atrophy (from the loss of trophic influence, and not from disuse alone), also result from lesions of the nerve trunks, but not so rapidly as in lead-poisoning. The following **fourteen muscles** are supplied by the musculo-spiral nerve, either directly or indirectly—(1) Biceps, (2) triceps, (3) the anconeus, (4) supinator longus, (5) extensor carpi radialis longior, (6) extensor carpi radialis brevior, (7) extensor communis digitorum, (8) extensor minimi digiti, (9) extensor carpi ulnaris, (10) extensor ossis metacarpi pollicis, (11) extensor secundi internodii pollicis, (12) extensor primi internodii pollicis, (13) extensor indicis, and (14) supinator brevis.

In paralysis of the **posterior interosseous** alone, in injuries involving the external condyle, there is only partial loss of supination and extension, as the supinator longus and extensor carpi radialis longior are not affected, being supplied directly from the trunk of the musculo-spiral. Should this condition last any length of time, the paralysed muscles tend to increase in length from the constant tension of the still healthy muscles, while the latter in like manner shorten, as they have nothing to oppose them, consequently the fingers become flexed, and the hand crumpled up into a "*club-hand*," somewhat resembling that seen after bad cases of teno-synovitis, or in contraction of the palmar fascia. The **muscles supplied** by the posterior interosseous nerve are from 6 to 14, inclusive, of the list given under the musculo-spiral nerve.

In fractures of the **internal condyle** the **ulnar nerve** may be implicated in a similar way. In this case there will be great loss of power in the ring and little fingers, adduction and flexion of the thumb will be imperfect, and adduction and abduction of the index and middle fingers impaired, as the interossei are paralysed. The position the hand assumes in lesions of the ulnar nerve is known as the "*clawed hand*," or "*main en griffe*;" it is due to paralysis of the interossei allowing the opposing muscles to have it all their own way, the result being extension of the first and flexion of the second and third phalanges, the hand thus assuming the bird-claw position. It must be distinguished from a similar appearance found

in the disease known as "*progressive muscular atrophy;*" in this disease all the fingers are equally affected, but in paralysis of the ulnar, the ring and the little fingers are much more bent than the others, since the first two lumbrical muscles, which are supplied by a branch of the *median* nerve, escape. In traumatic cases of lesion of the ulnar nerve, the onset is sudden, not progressive, and the paralysis *precedes* the atrophy. Sensation is lost in the little finger and on the ulnar side of the ring finger; the paralysed muscles undergo rapid atrophy, and show the "reaction of degeneration." The atrophy is first and most clearly seen in the *abductor indicis* (first dorsal interosseous), and next in the short muscles of the little finger. In addition to these symptoms we have the usual trophic lesions of the skin and its appendages—glossy skin, loss of hair and nails, blebs, and chilblain-like ulcerations. The muscles paralysed are—(1) The flexor carpi ulnaris; (2) half of the flexor profundus digitorum; (3) the three short muscles of the little finger—abductor, flexor brevis, and the opponens minimi digiti; (4) one and a half muscles of the thumb—the abductor pollicis, and deep head of the flexor brevis; (5) all the palmar and dorsal interossei; and (6) the two inner lumbricales.

To treat these conditions, mechanical means must be used so as to prevent further deformity and remove that already existing, passive motion, massage, and galvanism to the paralysed muscles. In cases where the nerve is actually enveloped in bony outgrowths, it will be necessary to cut down and set it free. The musculo-spiral nerve may also be paralysed, partially at least, in those who use crutches ("*crutch palsy*") from pressure of the upper end of the crutch upon the nerve trunk: also by the axillary pad, in cases of fracture of the surgical neck of the humerus: sometimes also in coachmen, who fall asleep on the box with the reins twisted round the upper arm: and lastly, in those who have imbibed too much of the cup that cheers (?) and most certainly does inebriate, and have fallen asleep in consequence, with one arm hanging over the back of a chair, in that position of good-natured *abandon* and free-and-easy carelessness so characteristic a result of the too free imbibition of this beverage. This last form ("*Saturday night palsy*") is usually first discovered on Sunday morning, the patient, as a rule, applying for advice and explanation on the following

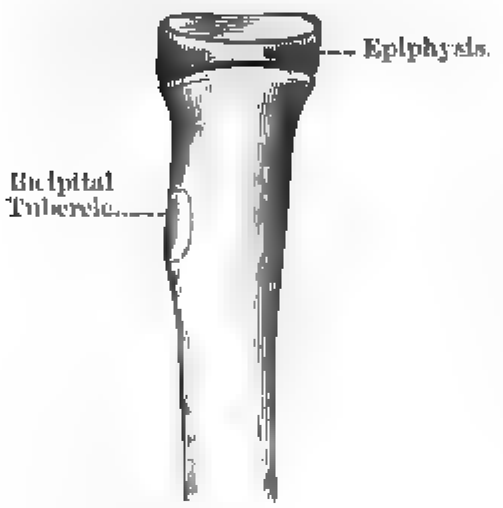
Monday. DUCHENNE has collected a large number of cases of sudden paralysis of this nerve, usually due, he believes, to cold, from sleeping with the arms exposed to a draught of cold air. While not denying the possibility of its being caused by draughts of cold air, still the usual cause, in this country at anyrate, would seem to be draughts of C_2H_6O. The best immediate **treatment** for this last condition is to apply electrical stimulation to the muscles; to stimulate the nerve trunk by applying some counter-irritant to the skin along its course—*e.g.*, iodine; and, for the future, to avoid "draughts."

BONES OF THE FORE-ARM.

Each of the bones of the fore-arm is **developed** from three centres. The centres for the shafts appear very early in fœtal life.

Fig. 86.

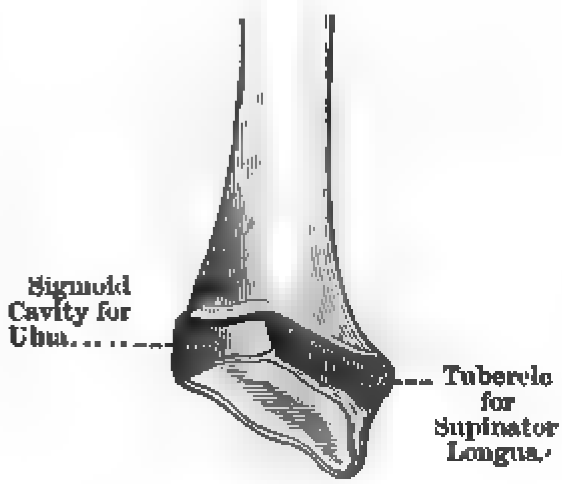
UPPER END OF RADIUS.



Unites about Puberty.

Fig. 87.

LOWER END OF RADIUS.



Unites about 20 years of age.

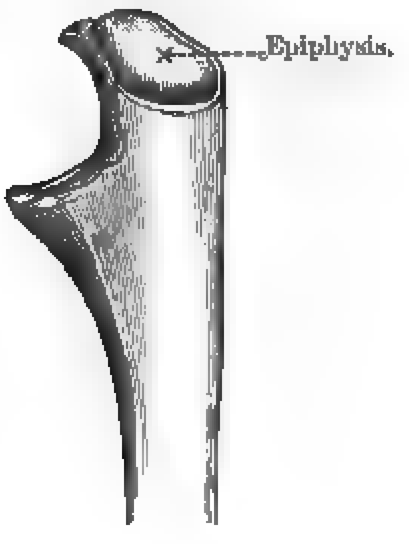
The **Radius** has also a centre for the head that appears at five years of age, and joins the shaft about puberty (Fig. 86), and another for the lower extremity which appears about the second year, and joins the shaft at twenty years of age (Fig. 87); the length of the bone is probably chiefly dependent on the lower epiphysis, although the contrary has been stated. The **Ulna** has a centre for the olecranon process, appearing at the tenth year and joining

2 F

the shaft about puberty (Fig. 88); and another for the lower extremity, appearing at the fourth year, and, like the radial one, joining the shaft at twenty (Fig. 89). The ulna grows in length chiefly from the lower epiphysis. Hence, it will be noticed that in both cases the upper epiphyses join the shafts at puberty, and the lower at twenty; and that the two centres for the ulna appear at exactly *double* the age as that for the radial centres—radial, five and two; ulnar, ten and four. The *upper* epiphysis of the radius is entirely within the orbicular ligament; the *lower* includes the facet for the ulna and the insertion of the supinator longus. As regards the upper end of the ulna, the coronoid process and the chief part of the olecranon are formed from an extension of the shaft of the bone into it; the upper part only of the olecranon is

Fig. 88.

UPPER END OF ULNA.



Unites about Puberty.

Fig. 89.

LOWER END OF ULNA.

Unites about 20 years of age.

developed from a separate centre. Next to the clavicle, the bones of the fore-arm more frequently present examples of *green-stick* fracture than other bones, usually the result of a fall on the hand or a twist of the arm in a young person. In adults either may be broken alone, but fracture of both together is more common. The lower end of the radius is not included in the previous statement, of course; if it were, then fracture of the radius alone occurs more frequently than fracture of any other bone—the clavicle, perhaps,

excluded—and at the lower end the fracture is very often impacted. The bones are throughout nearer the posterior than the anterior surface of the limb, and as the wrist is approached the nearer the two bones come to the surface of the lateral aspects of the arm. The posterior edge of the ulna is subcutaneous from the olecranon process to the wrist, and can, therefore, be readily examined in cases of supposed fracture. The upper third of the radius is pretty deeply covered, though its *head* is quite superficial, just immediately below the external condyle of the humerus; in the lower two thirds it is quite subcutaneous on its outer aspect. However, fractures of this bone are best detected by noting whether the head of the bone follows the movements of the wrist during pronation and supination, the Surgeon placing his left thumb on the head of the radius.

The Olecranon Process.—Fractures of the olecranon are usually the result of direct violence, and may be divided into—(1) Those with displacement, and (2) those without. The latter variety is the more common. Of the latter there are three forms—(*a*) The *transverse*, where the periosteum and ligaments are intact and effectually resist the action of the triceps to separate the fragments; (*b*) where the process is split obliquely, or longitudinally, or almost stellate; and (*c*) where the tip is broken off obliquely from behind forwards and downwards, leaving the unbroken posterior part attached to the triceps. The fracture may be caused by the action of the triceps muscle, or by a fall or a blow with a stick on the bent elbow. It occurs most frequently in men during the middle period of life. When the fragment is carried up by the triceps there is a hollow at the back of the joint, which is increased during flexion; and there is partial or entire loss of extending power. In other cases the dense periosteum, strengthened by a ligamentous expansion from the triceps muscle and the internal lateral ligament (= "*ligament of* Sir Astley Cooper"), is not torn, and in these cases there will be little or no displacement; the only symptom being special tenderness at one spot, or in the line of the fracture, and probably mobility and crepitus—the upper fragment moving on the lower. The line of fracture is usually about the middle of the process, often across the constriction or groove in the middle of the greater sigmoid cavity.

Treatment.—The indications are—(1) to keep the triceps muscle relaxed, to enable (2) the detached portion to be brought into and kept in its natural position by mechanical means—in other words, the arm must be kept extended during the healing of the bone. This is the *only* injury in the region of the elbow joint that should be treated in this position; all other injuries here are best treated in the flexed position. A splint, not exactly straight, but cut so as to correspond to the angle made by the fore-arm with the upper arm, is required; it may be made of wood, GOOCH splint, or gutta-percha, and should be long enough to reach from the middle of the upper arm to the wrist. The splint, as usual, must be well padded. *Before* applying the splint, in this special fracture, the fingers must be carefully padded, and the hand and fore-arm bandaged in the ordinary way, from the tips of the fingers upwards, finishing off with a *very lightly* applied figure-of-eight round the elbow, merely to retain the end of the bandage, and not to exert any pressure upon the joint; remember that this is the only fracture where it is lawful to apply a bandage *below* the splint, and it is advisable before applying it to encase the limb in a layer of boracic lint. The arm is to be thus bandaged to prevent venous congestion, which is apt to take place since the limb is kept in the extended position; and as the joint is wounded, blood is probably poured into it, and in any case synovitis, with extensive effusion, will almost certainly take place, hence the importance of avoiding tight bandages round the joint under the splint. The splint is then to be applied along the front of the limb, and bandaged to it in the usual way; and lastly, apply a few turns of a convergent figure-of-eight bandage above and below the olecranon, so as to press the fragments together, at first not very tightly, but as the swelling and effusion into the joint subside, more firmly. The tips of the fingers are left uncovered, so that the Surgeon may be able to judge of the condition of the circulation in the arm; blueness, coldness, and swelling will indicate that the bandages are too tight. The splints must be looked to on the second day to see if all is well. Passive movement must be gently tried from a fortnight to three weeks after the injury, the broken parts being firmly supported with one hand while the arm is moved with the other. Probably some form of gentle elastic traction brought to bear on the upper

fragment alone, as it only is displaced, would be the most effective plan—something of the nature of MANNING's splint for fractured patella. The splint may be kept on for two or three weeks, and after this, gentle passive movement practised, and a week or so later the splint may be entirely abandoned. The union is usually fibrous, bony being rare, except in cases where there has been no separation of the fragments. In cases where the fibrous medium is too long, it may be removed by operation, and the fragments wired together.

Fracture of the Coronoid Process.—This is very frequently associated with dislocation of the ulna alone, or of both bones backwards, as, when broken, the ulna during flexion is readily projected backwards. When the ulna is brought into position again and the elbow flexed, crepitus is produced, but when the extending force is withdrawn it quickly passes back again to its former position. As already pointed out, this process is developed as a part of the shaft, and therefore can never be separated as an epiphysis. It is caused by falls on the palm with the elbow slightly flexed. The detached fragment will be pulled upwards by the brachialis anticus muscle. Fractures of the **head and neck of the radius** are very rare forms of accident. In fractures of the neck, the upper end of the lower fragment will be pulled forwards by the biceps muscle. The upper epiphysis may also be separated before the age of puberty; this epiphysis is entirely within the orbicular ligament and we must not therefore expect much displacement. The head may also be split or starred. The **Treatment** of these injuries is the same as that for fracture of the condyles of the humerus (see page 445).

Fracture of the Radius alone above the insertion of the pronator radii teres.—When the radius alone is fractured it is usually the result of *indirect* violence, as a fall on the hand. The upper fragment is flexed by the biceps, and fully supinated by the same muscle, and the supinator brevis; while the lower fragment is fully pronated by the pronator radii teres and the pronator quadratus. Hence the upper part is fully supinated, while the lower is fully pronated. It is important to bear this in mind while treating the case, as first pointed out by LONSDALE. The fracture is best diagnosed by gently pronating and supinating the hand, while a finger or thumb is placed over the head of the

radius just below the external condyle; if the head moves with, and as fast as, the hand and lower end of the radius, there can be no fracture.

Fracture of the Radius below the insertion of the pronator radii teres.—Here the fracture is between the two pronators and the upper fragment is drawn upwards; or, rather, it tends to be tilted forwards and supinated by the biceps, and inwards by the pronator radii teres. The displacement inwards, however, may not be great, as the pronator radii teres is powerfully opposed by the supinator brevis and biceps, so that the bone retains a position midway between pronation and supination. The upper fragment is therefore held between the supinator brevis and biceps on the one hand, and the pronator radii teres on the other, nearly in its proper position. The lower fragment is drawn towards the ulna, and pronated by the unopposed action of the pronator quadratus, while the supinator longus tilts up the styloid process and depresses the upper end of the fragment; the lower fragment therefore usually lies in front of the upper. There is a swelling in front and behind, and the hand falls in and is *pronated* (compare with COLLES's fracture).

Fracture of the Ulna alone near its middle.—This is usually the result of *direct* violence, because the bone is so superficial, as in carrying something in the hands, *e.g.*, a tray, when the foot slips, and, to save the contents of the hand, the whole force of the fall is received on the posterior edge of the ulna. So also it may be broken by a blow from a stick when the arm is held up to protect the head; or in falling against the edge of a door-step. In this case there is but little displacement of the upper fragment, except that it is drawn a little nearer the radius by the pronator radii teres and forwards by the brachialis anticus; the lower fragment is drawn towards the radius by the pronator quadratus, and the extensors and flexors tend to draw it upwards. Although the displacement, due to muscular action, may not be great, yet the force that breaks the bone may cause a good deal, as it forces the broken ends towards the radius, narrowing the interosseous space. It is very difficult to treat this fracture, as the ends fall inwards and we have no power to act directly upon them to bring them into a proper position.

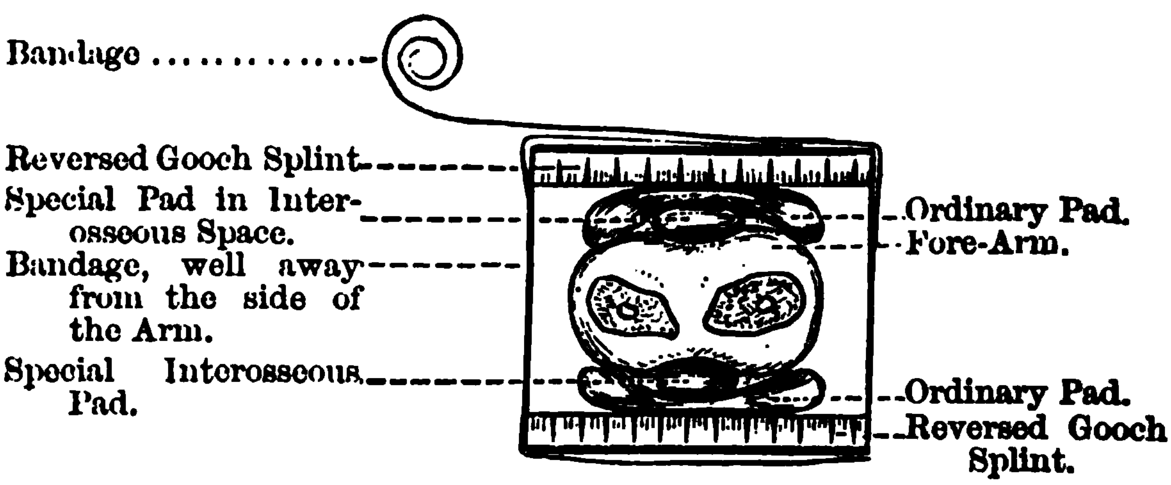
Fracture of both Bones.—The bones of the fore-arm are more frequently broken together than either the radius or ulna alone. The usual **cause** is *direct* violence, as a severe blow, or the passage of a wheel over them, and they, therefore, give way opposite each other. But it may also be caused by *indirect* violence, when the bones gave way at their weakest parts. One case is quoted, on the authority of MALGAIGNE, where muscular action, during digging, was the cause of the fracture. The usual position of the fracture is about the middle or lower thirds. As regards the displacement this will necessarily depend a good deal on the cause of the fracture; in a general way, something like the following will happen:—The **Upper Ends.**—The *radius* is tilted forwards by the biceps, and inwards by the pronator radii teres, and the ulna is tilted a little forwards by the brachialis anticus. The **Lower Fragments.**—The *radius* is pronated, and the two bones are approximated by the pronator quadratus, and are drawn upwards and forwards, or upwards and backwards, according to the obliquity of the fracture, by the flexors and extensors. The diagnosis depends on the pain, loss of power, unnatural bend of the fore-arm, crepitus, and the ease with which we can obtain mobility in the continuity of the bones, after fixing their upper ends.

Treatment of Fracture of the Shafts of one or both Bones.—The great objects are—(1) To keep up the full breadth of the interosseous space throughout, as this is essential to the movements of pronation and supination; (2) to command the elbow, wrist, and finger joints, in order to prevent non-union; and (3) carefully avoid pressure in the flexure of the elbow joint, and on the ball of the thumb. The bones are to be set by extension and counter-extension, applied to the upper arm and wrist by two assistants, while the Surgeon manipulates the bones into position. Two splints are required, rigid, and *broader* than the arm; GOOCH, or ordinary wooden splints may be used; but if GOOCH be used, the splints must be padded on the *wooden* side, and not on the leather side, as in most cases of fracture—*e.g.*, of the humerus. They must be broader than the arm so as to prevent pressure by the bandages on the lateral aspects of the bones, as this would force them together and narrow the interosseous space (Fig. 90). The posterior one must reach from the olecranon process to the

tips of the fingers; the anterior one must reach from the elbow to the roots of the fingers, and have a portion removed, if necessary, at the outer side of the lower end to avoid pressure on the ball of the thumb. Before applying the anterior splint the elbow joint should be bent to a right angle, otherwise this splint is apt to be carried too for up, and when the arm is bent *afterwards* the end of the splint presses injuriously in the flexure of the joint and may cause gangrene. They must be well padded as usual, but in addition a small "graduated compress"-like pad is to be placed lengthwise in front and behind, so that it may press the muscles of the fore-arm into the interosseous space and tend, at least, to keep the bones from falling together. The hand is then

Fig. 90.

FRACTURED FORE-ARM PUT UP.



placed midway between pronation and supination, as in this position of the bones the interosseous space is widened to nearly its fullest possible extent; the elbow is next bent to a right angle, the graduated compresses applied over the front and back of the interosseous space, and the splints applied and fastened by a continuous bandage, to finish off by a lightly applied figure-of-eight round the elbow—if preferred slip knots may be used instead, as in the upper arm. The arm must then be slung in a position midway between pronation and supination—the thumb uppermost, and pointing towards the patient's face. Over all an external rectangular splint extending from the shoulder downwards to the tips of the fingers should be applied to insure perfect immobility of the broken ends, by fixing the elbow, wrist, and finger joints.

But inasmuch as the power of supination is sometimes lost, it is said from the union of the radius in a bad position, the upper

fragment being fully supinated while the lower is fully pronated, it was first recommended by EDWARD LONSDALE, in 1832, and more recently by MALGAIGNE, that the arm should be put up in complete supination. It is impossible to bring the upper fragment of the radius into good position with the lower, and therefore, the next best thing to be done is to put the lower fragment into as good position as possible with the upper, otherwise the use of the supinator brevis and biceps, as supinators, is entirely lost, as they have already fully supinated the bone and are fixed in that position. The difficulty is best overcome by putting up the fractured arm in the position of full supination.

The limb must be kept perfectly rigid for at least two or three weeks, when the fingers and wrist may be allowed some freedom of movement. But as the fracture is not near a joint, there is less danger of adhesions forming in the sheaths of the tendons; indeed, absolute and long continued rigidity rather is indicated, as the fracture is through the compact tissue of the shaft, to avoid non-union. The bones unite in about five weeks.

COLLES'S FRACTURE.

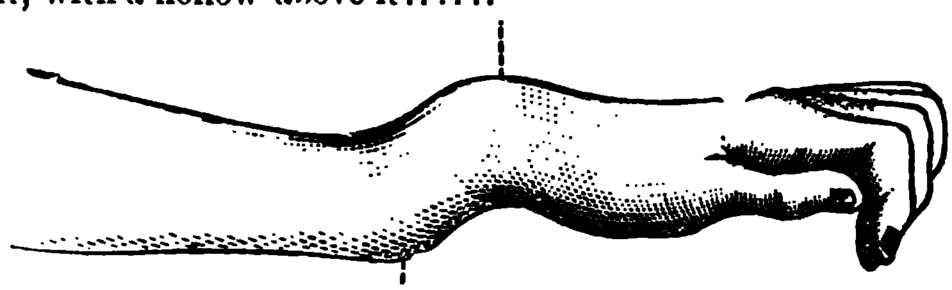
Fracture of the Lower End of the Radius.—The fracture in this case is for the most part below the origin of the pronator quadratus, and is usually about three-quarters of an inch, or rather more, above the articular surface, as seen from the front, but extends higher up on the posterior aspect, as it is usually oblique from before backwards. The **cause** is usually *indirect* violence, as a fall on the palm of the outstretched hand, the whole weight of the fall being transmitted through the ulnar side of the hand to the lower end of the radius, as it is three-quarters pronated, so that the ulnar border first touches the ground, and the hand is thus driven to the radial side; when caused by a blow on the palm, there is no lateral displacement. The fracture may be non-impacted, but is usually impacted. **Varieties.**—1. Where it is very near the lower end of the radius, comminuted, and non-impacted, and therefore easily reduced. 2. Higher up (the usual site) and not comminuted. This may be—(*a*) Impacted, or (*b*) non-impacted. Any fracture of the lower end of the radius, within

two and a half inches of the wrist joint, is called a "COLLES'S fracture." Next to fracture of the clavicle, the lower end of the radius is most frequently broken; and fracture of both wrists ("double COLLES'S") forms the commonest double fracture. From thirty years of age onward it occurs with increasing frequency in women. The great sign of this fracture is *deformity*, being caused in the first instance by the force that breaks it, and kept up by the impaction and by the extensors of the wrist and thumb, as well as all the other flexors and extensors passing over the broken radius. The radius is very frequently splintered into the wrist joint (CHIENE). The *lower* fragment is drawn upwards and backwards and to the radial side by the supinator longus, flexors,

Fig. 91.

COLLES'S FRACTURE—SIDE VIEW.

(To show the "Spoon-shaped" Deformity.)

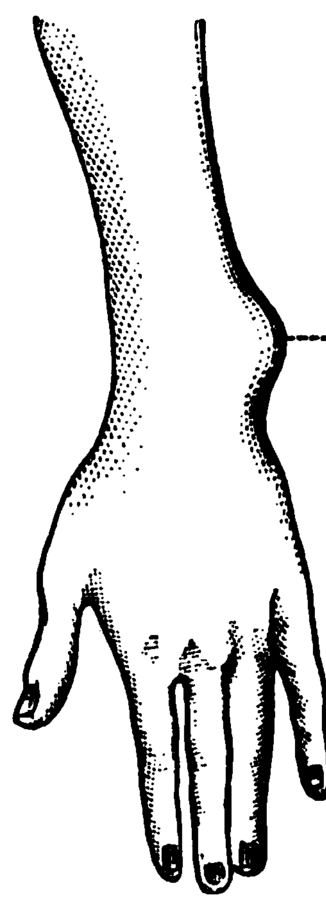


and extensors of the thumb and carpus; the *upper* fragment is not displaced (CHIENE), though it seems to project forward. Thus we have a prominence on the back of the wrist and a hollow above it, caused by the lower fragment, and a projection in front, where there ought to be a hollow, caused by the lower end of the upper fragment, the whole forming a peculiar spoon-shaped deformity (Fig. 91). It resembles dislocation of the carpus backwards, but may be distinguished from it by the fact that the deformity is removed by extension, and by the presence of crepitus in fracture, and the normal relation of the styloid processes to each other in cases of dislocation. It also simulates separation of the epiphysis of the lower end of the radius, but the age of the patient will aid the diagnosis. It should be noted, in cases of separated epiphysis

in young persons, when the bone unites, that this end of the radius will not grow to its usual length, while the ulna grows normally, and therefore the hand will be gradually pushed to the radial side, probably simulating a badly-treated COLLES. This fracture must also be diagnosed from **fracture of the lower end of both radius and ulna**; in this case there is greater mobility, and the whole hand, with the lower ends of the radius and ulna, is carried straight backwards, and lies in a straight line with the fore-arm, and is not abducted, as in COLLES's fracture. This injury more closely simulates dislocations of the wrist backwards. It must

Fig. 92.

COLLES'S FRACTURE—DORSAL VIEW.



also be diagnosed from **sprain of the wrist joint**; in sprain the tender area is over the line of the joint, whereas in fracture it is some distance above the joint. But the lower fragment, besides being displaced upwards and backwards, undergoes a rotation on its transverse axis, whereby the carpal articular surface comes to have an inclination backwards instead of forwards, as in the normal bone; hence the difficulty in flexing, though extension is easy. It is also slightly rotated on its antero-posterior axis, whereby the outer (radial) side of the bone is more shortened

than the inner (ulnar) side, as the strong inferior radio-ulnar ligaments oppose the displacement at that side, and it is in this way that the hand is inclined to the radial side, as well as being slightly dorsiflexed. The head of the ulna seems unduly prominent (Fig. 92), but this is not due to any displacement of the bone, but is due to the hand being displaced to the radial side and carried away from it, so that the styloid process seems carried forwards, as well as being too prominent. Very frequently there is a specially tender spot over the articulation between the radius and the ulna. The fracture is to be recognised by the appearance of the hand, history of the case, age of the patient, and by the fact that he is unable to supinate the fore-arm; and, by passing the fingers gently along the posterior surface of the lower end of the radius, the ridge formed by the displaced upper end of the lower fragment will usually be felt. Also the prominences and depressions about the wrist, the flexion of the fingers, and prominence of the head of the ulna, and, above all, the position of the styloid processes—in health, the styloid process of the radius is on a lower level than that of the ulna; but in fracture the position is reversed, the ulnar being on a level with, or below, the radial. Another symptom of some importance is the obliteration of the natural hollow on the front of the lower end of the radius, its place being occupied by a prominence.

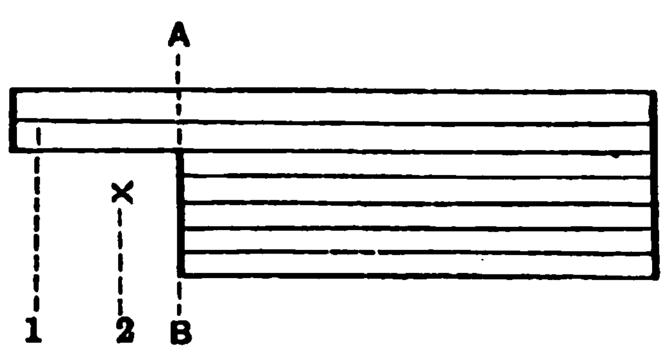
According to Professor CHIENE, when a person falls on his palm, if the angle between the fore-arm and the ground is *less* than sixty degrees, the whole shock is borne by the lower end of the radius, and a COLLES's fracture is the result; but if the angle be *greater* than sixty degrees, the shock passes up the bones of the fore-arm, and the result is either a severe sprain of the wrist, or a dislocation of both bones backwards at the elbow. When a person, with the wrist in extreme flexion, falls upon the knuckles and dorsum of the metacarpus, a fracture is sometimes produced the very reverse of COLLES's; it is usually known as "**Smith's fracture.**"

Treatment.—The bone, in ordinary cases, is placed in position by extension, counter-extension, and manipulation; in difficult cases it may be necessary to employ forcible and full flexion with twisting, before it is replaced, and sometimes it will require to be forcibly bent over the Surgeon's knee. The backward rotation of the lower

fragment *must* be corrected, else the patient will not be able to flex his wrist afterwards to any extent. Even in well set cases the styloid process of the ulna usually remains too far forwards. Two splints (GOOCH) are required—the anterior one (Fig. 93) must not extend further than the *centre of the palm*, so that the fingers may be freely flexed from the very first; on its radial side a large piece must be cut out for the prominence of the muscles of the thumb, and also extending upwards as far as the lower end of the upper fragment (some Surgeons only bring the anterior splint as far as the lower end of the upper fragment). This gap is to allow the lower fragment to be pushed forwards, in order that the natural

Fig. 93.

ANTERIOR SPLINT FOR COLLES'S FRACTURE.



1. That part of the splint that runs along the front of the ulna, and extends as far as the centre of the palm; the splint is sometimes used without this part.

2. The gap for the muscles of the thumb, *and to allow the lower fragment to be pushed forward.*

A and B—This line must not come further down than the lower end of the *upper* fragment.

hollow of the radius may be reproduced when the bones have united. The posterior splint extends to the knuckles. Both splints are to be well padded and applied; but a specially thick pad must be placed under the posterior splint opposite the lower end of the radius, in order to push the lower fragment well forward towards the palmar surface, into the gap in the anterior splint. The splints are then to be fastened on, first by a couple of slip-knots and then by a roller bandage, *secundum artem*, and the arm slung midway between pronation and supination. On account of the large number of tendons around this fracture it is most important to begin passive movement very early, especially

in old persons. The fingers and thumb are left free, and moved regularly from the very first, and at the end of the fourth or fifth day the splints are to be taken off, and the Surgeon, placing his index and middle finger over the upper end of the lower fragment, and his thumb on the lower end of the upper fragment, keeps the bones in position, while he gently moves the wrist with his other hand. This must be done every second day till the bones have united—at the end of three or four weeks. There is little or no danger of non-union, as the fracture is through the cancellous tissue, but there is *great* danger of a stiff and useless wrist resulting, especially in old persons. There are many other forms of splints used; but the results of the above simple method, that generally adopted in Edinburgh, are so satisfactory that it is quite unnecessary to seek refuge in more complicated, expensive, uncomfortable, and less efficient apparatus. Among them may be mentioned, the "pistol"-shaped splint, GORDON's splint, CARR's splint, etc. One objection, it seems to me, to most of these special splints, is that the hand is *displaced* as far in the opposite direction by the splint, as that caused by the force that broke the bone in the other direction. That the wrist is extended and the hand displaced to the radial side, is no reason, surely, why it should be unduly flexed and turned as far to the ulnar side—unless, indeed, it be to test the truth of the parallelogram of forces; but in this case it is scarcely necessary to point out that the two forces must act *simultaneously* on the point in question. The "pistol" splint is specially objectionable, as it almost invariably leads to a stiff wrist—the very thing we most wish to avoid.

RÉSUMÉ of the fractures about the wrist joint:—

1. COLLES's fracture, known by the marked deformity and the altered position of the styloid processes to each other.
2. SMITH's fracture, where the deformity is reversed.
3. Separation of the lower epiphysis of the radius, known by the age of the patient—below twenty.
4. Fractures of both bones just above the wrist—marked deformity, but hand in a straight line with the fore-arm.
5. Fracture just above the pronator quadratus; the hand turns in and is fully *pronated*.

These must be distinguished from *dislocations* of the wrist, by the fact that in dislocation the styloid processes maintain their proper relations to *each other*, but are altered with respect to the metacarpal bones, as well as other signs.

Fracture of the **Metacarpal Bones** is usually **caused** by direct violence, as by striking a blow with, or falling upon, the closed fist; it is more often met with in men, and in them during the period of active adult life, and usually towards the end of the week (pay-day), or about Christmas and the New Year. There are two **varieties** of this fracture—(1) The oblique, and (2) the transverse. In the *oblique* form there will very likely be shortening of the finger connected with the injured metacarpal, but in the *transverse* form there is no shortening. The fracture is to be **diagnosed** by running a finger along each metacarpal bone and carefully watching for any tender spot or marked deformity; this can easily be managed, as the bones are so subcutaneous. We may also grasp the two ends of the bone and try for mobility in its continuity; then place the hands palm to palm, and observe if the corresponding finger of each hand is of the same length as its fellow. Next, we may press the end of each finger towards the wrist; this will cause pain at the fractured spot should such exist, but if it be merely a bruise, there will be no pain felt at the injured spot. Lastly, make the patient clench his fists, and compare the line of the knuckles in the two hands, noting any fulness or depression. It should be noted that a "stave" of the thumb may produce a contusion of the meta-carpo-phalangeal joint or split the head of the metacarpal bone. Fracture of the metacarpal bone of the thumb usually presents no difficulty in diagnosis, as it is free on all sides; the metacarpal bones of the index and little fingers are more difficult, and those of the middle and ring fingers the most difficult of all, on account of their relation to the other bones.

Treatment.—First Method, to be used in the case of transverse fracture of the metacarpal bones of the middle and ring fingers. Direct the patient to grasp a ball of soft worsted in the palm of the injured hand, and bandage it in that position thus:—Carry an ordinary bandage in a figure-of-eight, beginning at the carpo-meta-carpal articulation of the thumb, over the back of the fist, and then round the front of the second phalanges of the fingers, but not

including the thumb, then over the back of the hand to the ulnar side, and then take a turn round the wrist, thus completing and fixing the figure-of-eight. On reaching the spot where we commenced, the roller is then carried forwards over the first and second fingers, taking care to leave a free margin hanging over the radial side of the index finger; now carry the bandage back over the palmar aspect, to meet at the same spot as before, and complete by a turn round the wrist. Repeat this three or four times, bringing each turn nearer the ulnar side, and at last leaving a free margin there, as on the radial side. Then carry the bandage round the wrist, as in the first figure-of-eight, being careful to catch and secure the free margins left at each side of the hand. Repeat this two or three times, and then take a turn round the wrist, and fasten.

Second Method, to be used in cases of transverse fracture of the metacarpal bone of the thumb, and probably also in the case of the index and little fingers as well. In the previous method, the neighbouring bones act as lateral splints to the ring and middle fingers. In the case of the others, however, it will probably be better to keep the hand straight and apply a well-padded splint along the anterior aspect, and bandage the injured digit in that position; and certainly always do so in the case of the metacarpal bone of the thumb—the one most frequently broken. Were they treated like the middle or ring fingers, the bandage would force the broken ends towards the other bones and lead to marked deformity.

Transverse fractures of the **Phalanges** must be treated by a well-padded, straight, anterior splint, with a specially thick pad opposite the middle of the broken phalanx, to fill up the hollow that naturally exists opposite the middle of the phalanges. In the case, however, of *oblique* fracture of the phalanges, or of the metacarpal bones, it will be necessary in every case to put up the fracture in the straight position and apply some form of extension. This may be accomplished by the use of an internal rectangular splint, passing some distance beyond the tips of the fingers, together with an elastic band brought over the lower end of the splint and then fastened to its upper end, while the other end is attached to a more or less complete finger-stool of sticking-plaster, which is in turn to be attached to the injured finger.

The **Metacarpal Bones** are **developed** by two centres—the four inner bones, one for the shaft appearing about the sixth week, the other for the head appearing about the third year, and uniting with the shaft at twenty. The metacarpal bone of the thumb has also two centres, one for the shaft and the other for the *base*, in this respect resembling the phalanges. The dates of appearance are the same as the others.

The **Phalanges** are also **developed** from two centres, one for the shaft appearing about the sixth week, and one for the base from the fourth or fifth year, and uniting between the eighteenth and twentieth years.

CHAPTER XXV.

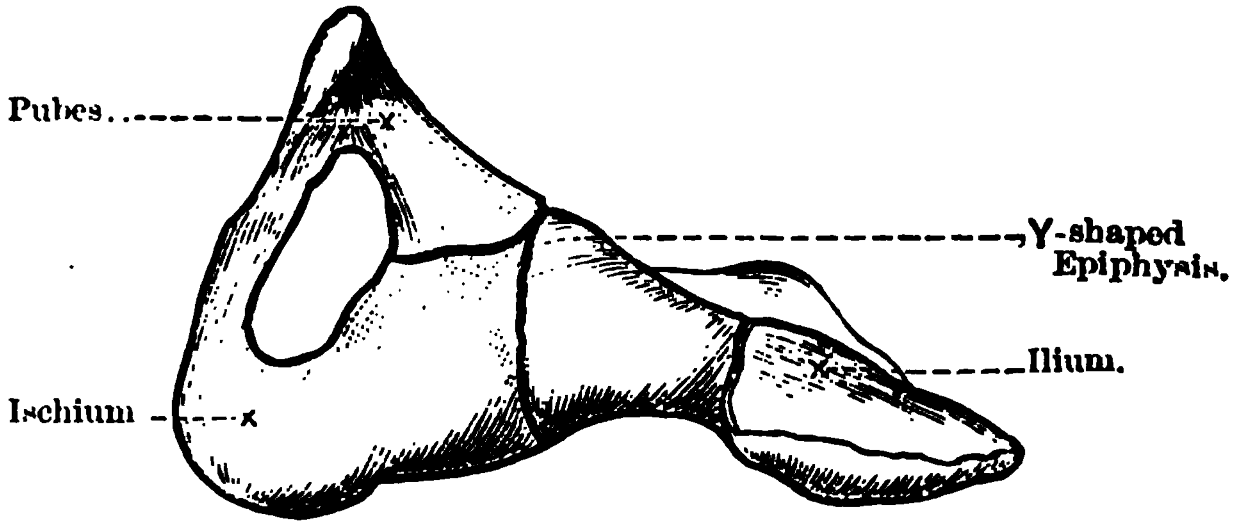
FRACTURES OF THE LOWER EXTREMITY.

THE PELVIS.

THE innominate bone is developed by eight centres — three primary and five secondary; the three *primary* — one for the ilium, the ischium, and the pubes respectively—unite through the Y-shaped piece at the bottom of the acetabulum, about puberty; the *secondary* centres appear about puberty and unite about the twenty-fifth year (Fig. 94). The secondary centres are—one for

Fig. 94.

THE INNOMINATE BONE.



the iliac crest, one for the tuberosity of the ischium, one at the Y-shaped junction of the three bones; one for the anterior inferior spine, most frequently seen in males; and one for the symphysis pubis, most frequently seen in females. It is important to remember the Y-shaped piece, as before its consolidation, pus, in hip joint disease, may readily pass through into the pelvis.

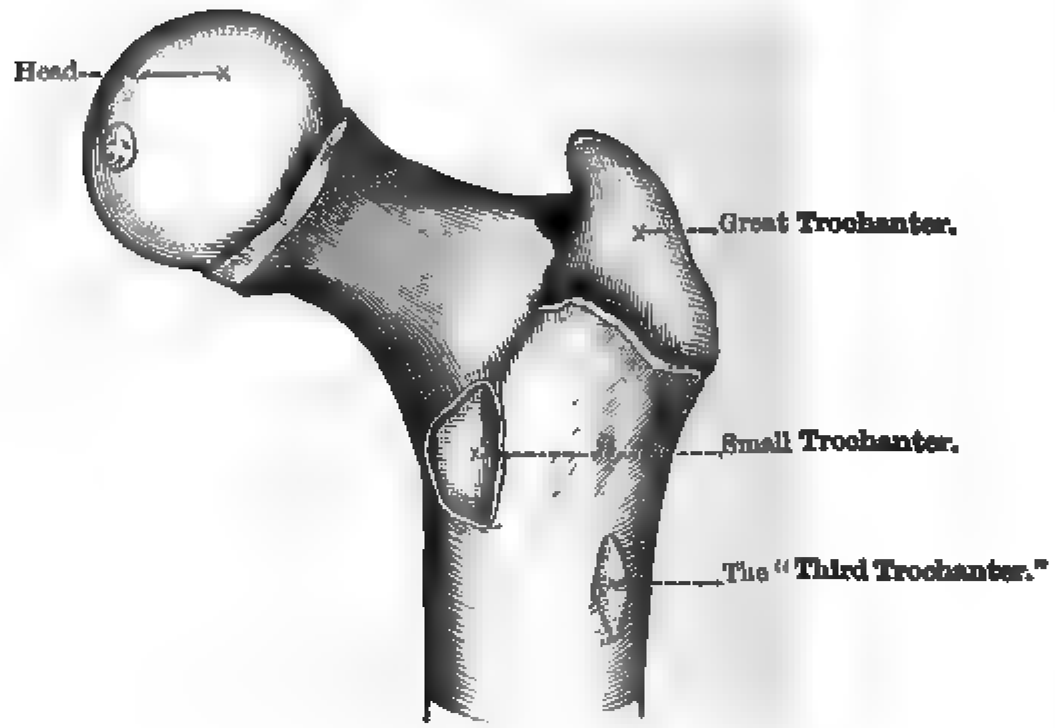
The pelvis may be broken by crushes between a cart and a wall, mining accidents, in railway collisions, etc. (*a*) The **False Pelvis** is usually broken by lateral crushes; but fracture of this part is not so serious as fracture of the true pelvis. (*b*) The **True Pelvis**—This is most likely to suffer from antero-posterior compression; the great danger of this fracture is injury to the various pelvic viscera, especially the urethra, bladder, and rectum. The membranous part of the urethra is most apt to be injured, as the fracture very constantly passes through the rami of the pubes and ischium, and is therefore very near the urethra. To detect fracture of the false pelvis, grasp and try to move the iliac crests. For the true pelvis, feel the rami of the pubes and ischium; but in every case it will be wise not to make a too exact diagnosis, lest a sharp spicule of bone be pushed into the urethra or bladder.

The Anterior Inferior Spinous Process may be torn off by the rectus, in running or jumping, more especially before complete consolidation—the twenty-fifth year.

Treatment.—The chief point in the treatment of the case is **never to let the patient attempt to pass water**, but the Surgeon should at once try to pass a catheter into the bladder—gum-elastic if possible. If the urethra is ruptured, the patient would simply make water into his perinæal tissues on any attempt at micturition, unless, fortunately, the centres for that act were paralysed by the shock. If, when the catheter is passed, clear urine is drawn off, it shows that the bladder is not ruptured. Should the urine be bloody it may point to various accidents, but at any rate, in all cases of doubt a soft catheter should be tied in and a syphon arrangement attached to it, so that the urine may drain away as soon as it enters the bladder. In passing a catheter, keep its point well against the upper wall of the urethra, as this part is less likely to be torn than the lower part of the circumference The pelvis is then to be steadied by a broad flannel bandage with plenty of wadding below, and a double spica over all. The prognosis is fairly good, so far as immediate danger to life is concerned; *but* ever afterwards the patient will be the subject of the worst possible form of organic stricture—the traumatic—with all its secondary risks to the genito-urinary organs, situated behind the stricture.

Fig. 95.

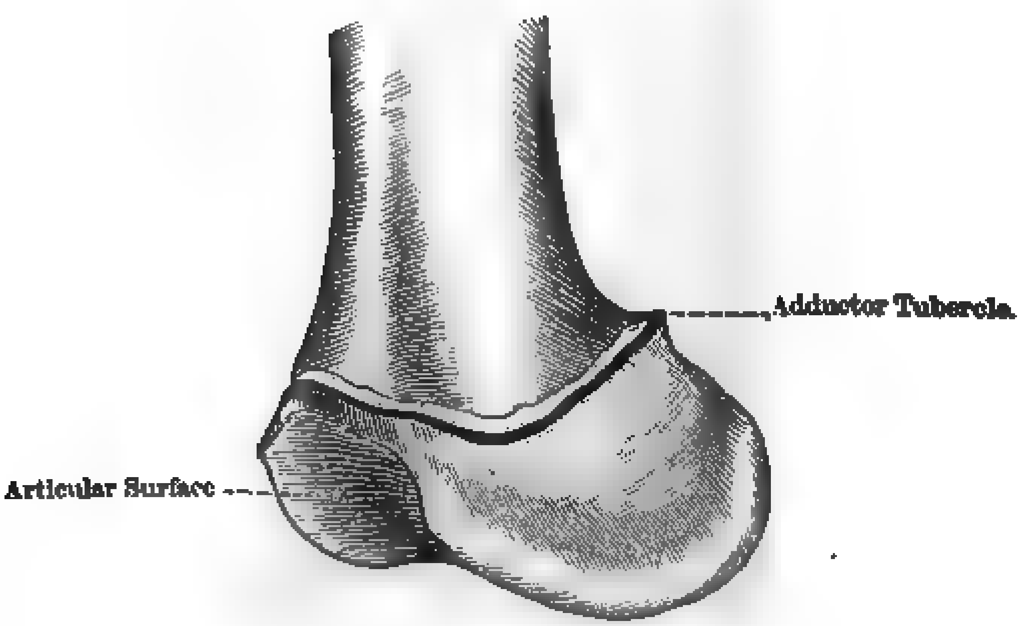
UPPER END OF FEMUR.



Union complete about 18 years of age.

Fig. 96.

LOWER END OF FEMUR.



Joins the shaft at 20 years of age.

THE FEMUR.

This bone is developed from five centres, that for the shaft appearing soon after the centre for the clavicle. At the upper end there are three centres—one for the head, which appears at the end of the first year; another for the great trochanter, which appears during the fourth year; and a third for the lesser trochanter, which appears between the thirteenth and fourteenth years. All the three join the shaft about eighteen (Fig. 95). There is only one centre for the lower end of the bone, and that appears *two weeks* before birth and joins the shaft at twenty years of age (Fig. 96). The presence or absence of this centre is an important sign of the maturity or otherwise of newly-born children, found dead, in medico-legal cases. For medico-legal purposes also, compare the development of the femur with the humerus: the *lower* end of the *humerus* is complete at eighteen, the *upper* end at twenty; in the *femur* it is the reverse, the *lower* end is complete at twenty, and the *upper* end at eighteen. A knowledge of these facts, together with the dentition—all the teeth being present except the wisdom, and the presence of an ossifying centre in the epiphysis of the clavicle, which appears about eighteen,—would enable one to speak with considerable assurance upon the age of a body, say of eighteen years, though reduced to a skeleton. Observe the great number of epiphyses in the neighbourhood of the hip joint—three in the femur, and the Y-shaped one at the bottom of the acetabulum. This, no doubt, explains the very great frequency of hip disease (*strumous arthritis*) in early life, as probably in most cases the disease begins at the growing line of the bone, as there the tissue is nearest the embryonic type, and the vascularity is great, so that any slight stimulus is enough to convert the physiological hyperæmia into pathological congestion. It also explains why it is that the femur should be attacked more frequently than the acetabulum: one would expect the femur to be attacked three times as often as the acetabulum. It will be noticed, therefore, that, as usual, the order of union of the centres is the reverse of their appearance. The femur grows in length chiefly from the lower epiphysis. The line of this epiphysis just passes through the "*adductor tubercle*" and immediately above

the highest part of the articular surface, being deeper, in vertical extent, on the inner side than it is on the outer (Fig. 96). It includes, therefore, part of the tendon of the adductor magnus, practically all the inner head of the gastrocnemius, probably all the outer head too, as it is attached at a lower level and more external than the inner, and the tendon of the popliteus; the plantaris is attached to the shaft of the femur.

In the *adult* the neck of the femur forms an angle of 125 degrees with the shaft; in *children* the angle is even more oblique; and in *old age* the neck drops nearly to a right angle with the shaft, and not only so, but its cancellous tissue undergoes fatty degeneration and interstitial absorption ("osteoporosis"), and its compact shell is also thinned. The femur is thickly covered by muscle throughout its entire extent; it is perhaps least thickly covered on the anterior aspect of its lower third.

Fractures of the Neck.—These may be—(*a*) Intra-capsular, and (*b*) extra-capsular. The following table will assist the diagnosis between intra-capsular and extra-capsular fractures of the neck of the femur—(From Erichsen):—

Intra-Capsular.	Extra-Capsular.
1. Cause—generally slight and indirect, such as catching the foot in the carpet or slipping off the kerb-stone.	1. Cause—usually severe and direct violence, such as falling from a height or blow on the hip.
2. Force—usually applied longitudinally or obliquely.	2. Force—usually applied transversely.
3. Age—rarely below fifty, most commonly in feeble, aged persons.	3. Age—usually below fifty, chiefly in vigorous adults.
4. Pain and constitutional disturbance slight.	4. Pain and constitutional disturbance usually considerable.
5. No apparent injury to soft parts about the hip.	5. Considerable extravasation, ecchymosis, and signs of direct injury to hip.
6. Crepitus often obscure.	6. Crepitus (when not impacted) very readily felt.
7. Shortening usually at first not more than one inch.	7. Shortening (when not impacted) at least two inches or more.

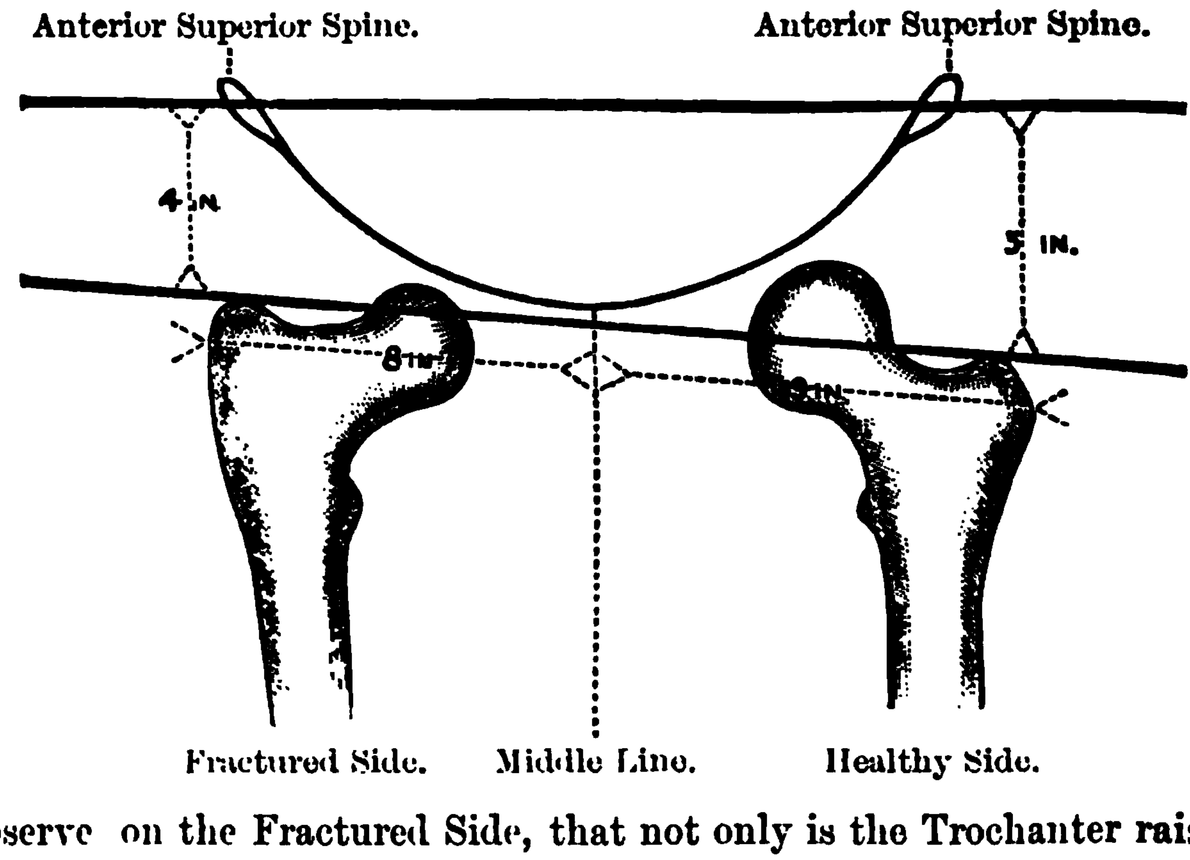
The limb lies extended and helpless, and there is usually marked *eversion* in both cases, partly perhaps because this is the natural position of the limb, but chiefly from the action of the psoas and iliacus muscles, the adductors, the glutei and other external rotators of the hip joint. The shortening of the limb is caused by the glutei muscles, rectus femoris, and hamstring muscles (biceps, semi-tendinosus, and semi-membranosus). The cause of eversion in impacted extra-capsular fracture is probably due, as BIGELOW has pointed out, to the thinness and less resisting nature of the compact shell of bone on the posterior surface of the neck of the femur, as compared with the anterior. It therefore yields more readily, "crushes up and becomes impacted."

Intra-Capsular may be either impacted or non-impacted. In impacted the lower fragment is driven into the upper. The **predisposing cause** is the changes already mentioned as occurring in the direction and internal structure of the neck of the femur; the **exciting cause**, some very slight *indirect* violence, as tripping on a stone, turning in bed, etc., and, as a result of the snapping of the neck of the bone, the patient drops down. It is especially apt to occur in women beyond a certain age. There are no signs of bruising in the first instance, but in three or four days a characteristic staining often appears in SCARPA's triangle, when the effused blood has had time to reach the surface. In some cases, probably from the nature of the cause, the fracture is, in the first instance, sub-periosteal, so that there would be little or no shortening, as the fragments are held in position by the periosteum, and the cervical reflection of the capsular ligament; but later, these structures soften and yield, either from the movements of the limb, or from inflammatory softening, as will also the capsular ligament itself, which is not, in the first instance, torn. In a few rare cases there may be *inversion* of the limb probably because more of the anterior part of the neck is crushed up than of the posterior, or else the anterior part of the cervical reflection is not torn. These facts explain the slow appearance of the shortening, so often noticed in intra-capsular fracture, and which is apt to mislead the incautious Surgeon; or, again, the sudden increase of shortening under manipulation. The limb lies helpless, extended and everted, but can be moved freely by the Surgeon in all

directions, probably with the production of crepitus; for this purpose the Surgeon places his hand flat over the great trochanter, while an assistant grasps the foot and gently rotates the whole limb. The great trochanter is raised as shown by BRYANT'S test, or the still simpler and more effective method used by Professor CHIENE (Fig. 97). On rotating the foot it will be noticed that the trochanter rotates round a smaller circle than the trochanter of the sound side. As the patient stands the knee is flexed somewhat and the heel raised. In the usual state of the parts, in health, blood is brought to the head of the bone by the ligamentum

Fig. 97.

FRACTURE OF THE NECK OF THE FEMUR.



Observe on the Fractured Side, that not only is the Trochanter raised, but it is also nearer the Middle Line.

teres, synovial membrane surrounding it, the thick periosteum and the cervical reflection of the capsular ligament. In non-impacted fracture of the usual kind, all these sources, save the ligamentum teres, and, perhaps, the synovial membrane, are cut off; for this reason it is said, and, perhaps, also because the parts are not kept in proper apposition, the union is usually by fibrous tissue only. In those that heal by *bone* it is presumed that the fracture has probably been impacted, or sub-periosteal, or not strictly intra-capsular.

Extra-Capsular Fracture is usually impacted, but may also be non-impacted. In the impacted variety the upper fragment is driven into the great trochanter, splitting it up and increasing its breadth, and the trochanter itself is carried nearer the middle line. It is equally common in both sexes, and most often met with during vigorous adult life from a severe direct blow to the outer side of the hip, but in older persons may result from a simple fall on the great trochanter. In the non-impacted form there is distinct crepitus, severe pain on attempts at movement, and great shortening; on rotating the foot the trochanter rolls round a smaller circle than on the sound side. In the impacted form there is great pain, but the patient may possess a considerable amount of power over the limb; there will also be eversion, slight shortening, usually about three-quarters of an inch only, and another very characteristic sign, viz., broadening of the great trochanter in the antero-posterior direction (CHIENE) together with free passive motion in all directions. Hence, given a case, where the patient has had a fall on the hip, with slight eversion, three-quarters of an inch of shortening and broadening of the great trochanter, there can be no doubt as to what has taken place—impacted extra-capsular fracture.

These simple tests further avoid all disturbance of the limb, save the patient from needless pain, and one escapes the risk of un-impacting an impacted fracture. If further confirmatory evidence is wanted then we can use the previous simple test for the position of the great trochanter.

From the fact that the anterior part of the capsule is attached to the anterior inter-trochanteric line, and as this point also marks the junction of the neck of the bone with great trochanter, it is therefore anatomically impossible to have an *extra-capsular fracture of the neck*, at least on the anterior aspect; but, at the lower and posterior part, the capsule is attached about three-quarters of an inch internal to the inter-trochanteric line.

In addition, of course, to these tests others may be used, as BRYANT'S, NÉLATON'S, and MORRIS'S: BRYANT'S line will be shortened from half to an inch, and the trochanter is nearer the middle line, as shown by MORRIS'S test. In fractures of the neck the ilio-tibial band is also relaxed (ALLIS).

Diagnosis.—Fractures of the neck must be distinguished (1) from **backward dislocations.** In dislocation we have marked *inversion* (except in the rare form of the everted dorsal), the *rigidity* of the limb in certain directions, the *absence of resistance* when the fingers are pressed into the upper part of SCARPA's triangle, the presence of the head of the bone in an abnormal position, and other signs of dislocation; specially note, therefore, the marked deformity and rigidity of the articulation. Sometimes, however, there is inversion in fracture of the neck, some say as a result of muscular action—the adductors, because the external rotators are torn off or paralysed by the injury—but it is more likely due to impaction in that special position, from the attitude of the limb at the time of the injury, or from the direction of the force. But in any case there will be the usual feeling of resistance in the groin; and, as the head of the bone is in its proper place, the Surgeon will be able to obtain passive movement freely in all directions, and there will probably be broadening of the great trochanter. It must also be distinguished (2) from the condition of the hip, met with in **chronic rheumatic arthritis,** where the appearance and symptoms closely resemble those met with in fracture. There is pain, loss of power, and rigidity, especially on passive rotation, shortening of the limb, and elevation of the great trochanter; but in this condition there is no history of injury to account for it, though, of course, a person suffering from chronic rheumatic arthritis may also be the subject of fracture of the neck of the femur, when the diagnosis becomes very difficult. In chronic rheumatic arthritis it may be possible to detect enlargement of the lips of the articular bones, and creaking during passive movement. The Surgeon must also be on his guard, and warn those who have received a fall or blow on the hip of the probable result—viz., a shortening of the limb taking place in the course of a few weeks, more especially in old persons, otherwise he may be unjustly blamed for having overlooked a fracture of the neck of the femur. It is a curious fact that this (3) **interstitial absorption of the neck** of the bone often follows blows on the hip, coming to resemble, after some weeks or months, a fracture of the neck, not only in the old, *but in young persons* as well, probably from some injury to the epiphysis, which has caused

it to ossify too soon, and hence the limb becomes shorter and shorter until growth is completed. But in this case there will be no broadening of the great trochanter; the shortening does not take place at the time of the accident, but after the lapse of some weeks, and comes on gradually, the patient being probably able to walk about all the time. In *any* injury of the hip therefore, especially in the aged, give a guarded prognosis, and tell them the possible, and even probable result.

Charcot's Disease.—This is a trophic lesion, depending on disease of the postero-external column (BURDACH's) of the spinal cord, and is but a symptom of locomotor ataxy. In many respects it resembles chronic rheumatic arthritis; but however close the resemblance may be, there are usually two marked differences—one is the absence of pain in the part, the other is the excessive mobility of the articulation.

Charcot's Disease.	Chronic Rheumatic Arthritis.
1. Very rapid and extreme wearing away of the articular bones, often leading to spontaneous dislocation.	1. Chronic in its course, and the wearing away is accompanied with excessive growth of osteophytes round the lips of the articulation; dislocation rare.
2. Often rapid and great collection of turbid serum, forming a large fluctuating tumour, filling up SCARPA's triangle and bulging behind as well.	2. This is essentially a *dry* disease—the cavity of the joint is usually very dry, though neighbouring bursæ may be enlarged from effusion, and *sometimes* the joint itself.
3. Its onset is acute, and its course is rapid and irregular, and it may subside partially or entirely.	3. Is essentially long-continued, and steadily progressive from bad to worse.
4. Absence of pain and stiffness of the affected joint; patient can readily move it.	4. Joint rigid, and there is great pain, especially at night.
5. Peculiar scrunch on moving the joint passively.	5. Dry creaking or crackling crepitation on passive movement.
6. Formation of osteophytes the exception.	6. The rule in this affection.

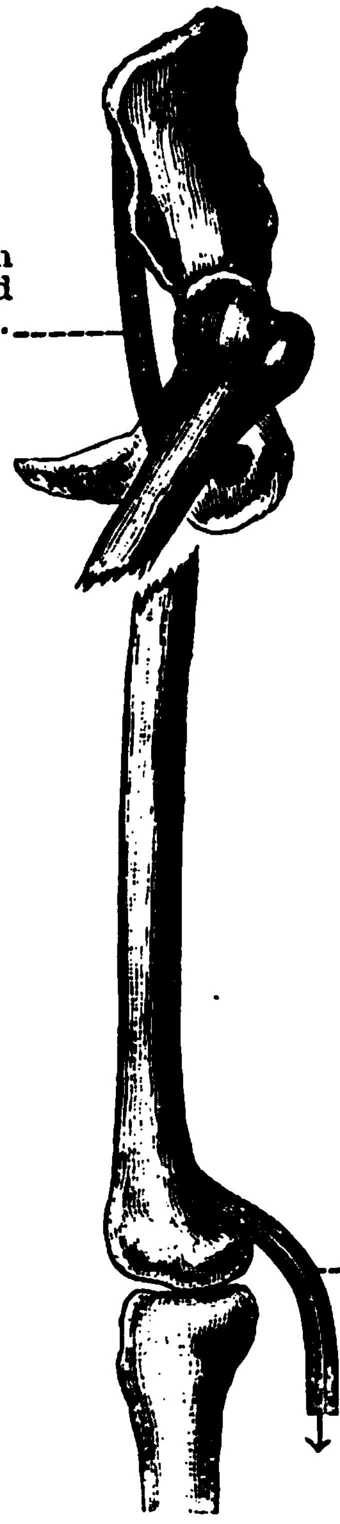
Accompanying CHARCOT'S disease we may likewise find some or all of the following symptoms—(1) Lightening and girdle pains; (2) loss of co-ordinating power, usually first observed by the patient in the dark, as in rising at night, or when his eyes are shut, as in washing himself in the morning, when he is apt to fall into the basin. It is also seen when he stands with his eyes closed and his heels close together, for then he sways from side to side, and will probably fall; he staggers also when he turns sharply round. (3) Loss of the patellar reflex; (4) ARGYLL ROBERTSON symptom; (5) temporary paralysis of the ocular nerves; (6) various forms of paræsthesia, such as numbness and formication, and delayed conduction of sensory impressions, especially of pain; and (7) crises of various organs, such as the stomach, intestines, and kidneys, but especially the stomach.

Treatment of Fractures of the Neck.—In *all* cases treat as if we meant to get bony union. The old plan was simply to keep the patient a week or two in bed, then allow them to rise and hobble to the end of life (often not far distant), with the aid of a friendly stick or crutch, as best they could. Many Surgeons seem to think that this is still the best method of treatment, with the addition, perhaps, of a well-fitted THOMAS'S hip splint. In spite of this treatment it occasionally happens that the fracture *unites* by *bone*, as some museum specimens show; and in cases where no union takes place, the capsule becomes so thickened in many cases that the patient may be able to walk about fairly well. Formerly the mortality from this accident was greater than that of amputation at the hip joint, the causes of death being failure of the general health, hypostatic congestion of the lungs, and bed sores; these, combined with imperfect nursing, very quickly finished the patient. Be careful to keep the buttocks and back *clean and dry*, the sheets smooth, and, if necessary, use a water bed; the use of the weight and pulley, too, with a single or double long side splint to prevent eversion, will do much to obviate the former dreaded and fatal dangers. In **impacted-fracture**, provided the shortening and eversion are not greater than usual, all that is required is simply to steady the limb by a double long splint, *without the use of any extension apparatus at all.* The bone must on no account be unimpacted, as it is in the very best possible

condition for bony union. (For the method of putting up the limb by the long splint, or weight and pulley, in fractures of the neck, see end of "Fractures of the Femur.")

Fig. 98.

FRACTURE JUST BELOW THE LESSER TROCHANTER.



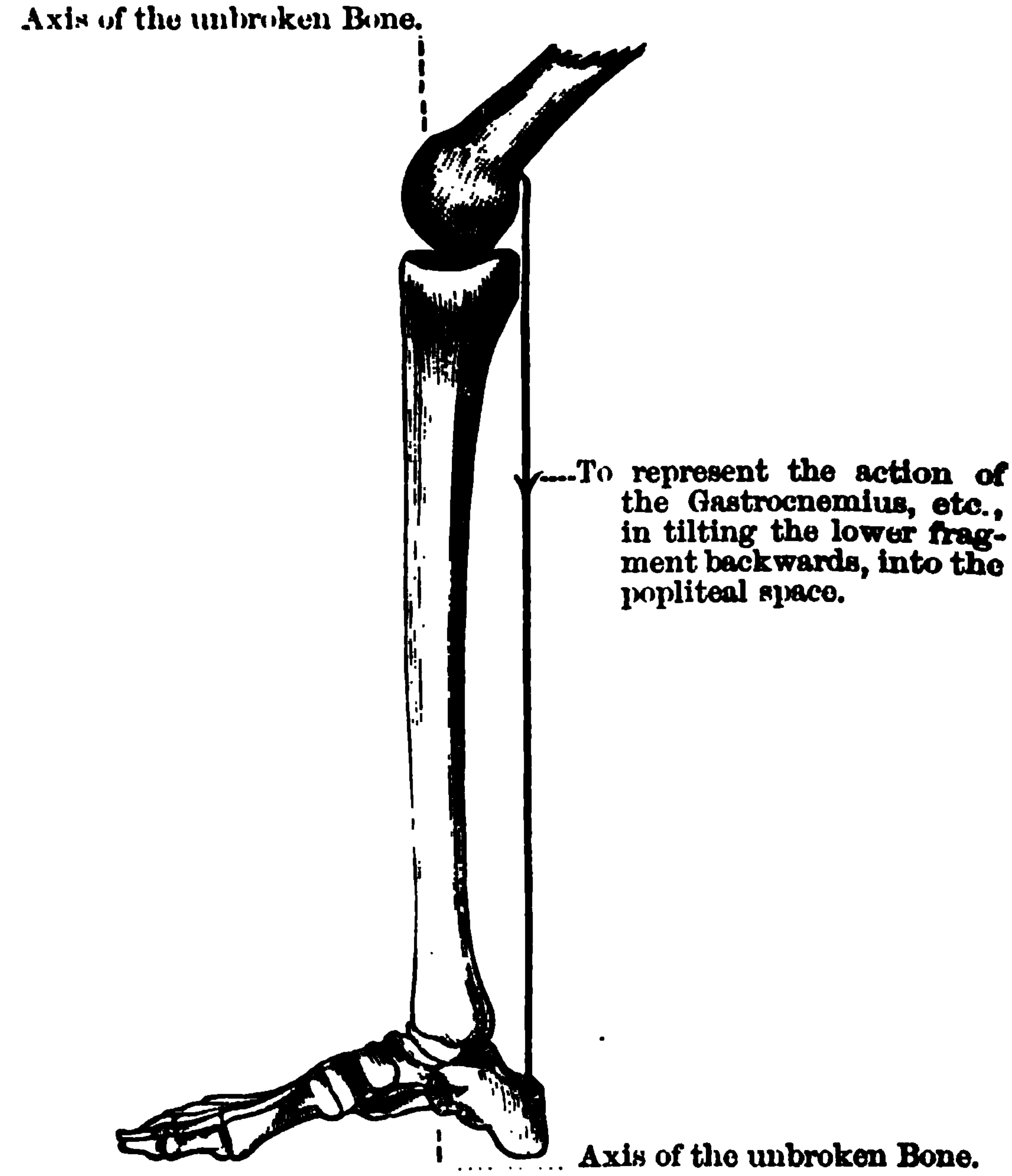
FRACTURES OF THE SHAFT.

Fracture of the shaft is very common in children, and is often transverse in direction and incomplete *(green-stick).* Excluding fractures of the neck, one-third of all fractures of the femur occur in children under ten. In adults the fracture is usually oblique, being caused by indirect violence, the bone giving about its middle

third. If the fracture be through the upper part of the shaft, below the lesser trochanter, the upper fragment is tilted forwards and everted by the psoas and iliacus, and drawn outwards by the external rotators and glutei muscles (Fig. 98); the lower fragment is drawn upwards behind the upper by the rectus femoris in front, and the hamstring muscles behind, and drawn inwards by the pectineus

Fig. 99.

FRACTURE NEAR THE KNEE JOINT.



and adductor muscles. Hence there is marked shortening, eversion, and crepitus. In treating this fracture it is very difficult to place and keep the upper fragment in proper position; this is because we have no power to act upon it directly, nor overcome the muscles attached to it. In fracture through the middle of the shaft, which is by far the most common situation, the lower fragment is drawn inwards and upwards behind the upper fragment by the adductor

fibres attached to it, and rotated outwards, probably by the weight of the limb and the adductor magnus; while the upper fragment projects forwards, usually from the same causes as in fracture of the upper part of the shaft, and is probably also tilted in this direction by the lower fragment slipping in behind it. In fracture in the **vicinity of the Condyles** the lower fragment is tilted backwards by the gastrocnemius, plantaris, and popliteus muscles, and can be felt deep in the popliteal space (Fig. 99), the upper end being tilted a little outwards by the tendon of the adductor magnus; the upper fragment is drawn inwards by the pectineus and adductors, and tilted forwards by the psoas and iliacus, but in many cases it remains very nearly in its natural position. In all cases of oblique fracture of the shaft of the femur there is shortening and external rotation—shortening being caused by the contraction of the flexors, extensors, and adductors of the limb, while external rotation is caused by the external rotators being more powerful than the internal. In children fractures of the shaft of the femur are frequently transverse, and, in such cases, the well-marked displacement is absent; and, in connection with fractures in the vicinity of the condyles in children, it should be borne in mind that diastasis of the condyloid end of the femur may take place—the lower epiphysis of this bone not uniting with the shaft till the twentieth year. Just as in the humerus, the great sign of fracture of the *shaft* of the femur is mobility in its length; fix the upper part of the thigh and get some one to move the leg gently from side to side.

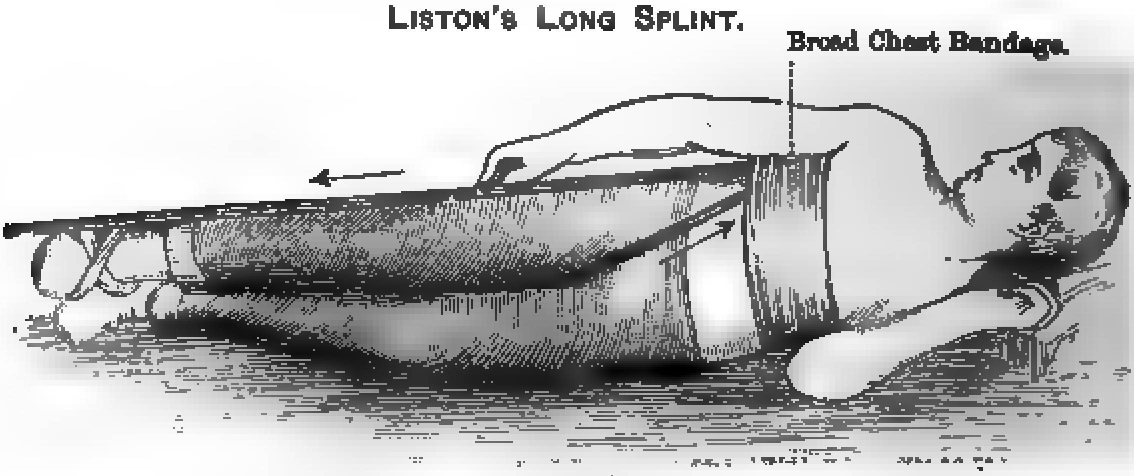
METHODS OF TREATING FRACTURES AT ANY PART OF THE FEMUR.

1. **The Long Splint.**—I begin with the "long splint," which is usually named after LISTON, not because it is the best method, but because it will be more convenient to describe it first, as the same apparatus may be used, but for a very different purpose, along with the weight and pulley; and doing so will, therefore, save repetition. In some cases, too, it may be impossible to use the weight and pulley—*e.g.*, where patients are cooped up in the time-honoured, but sadly defective (for the purposes of the Surgeon, and from a hygienic point of view as well) "box-bed." For the long

splint we require a board, four or five inches broad, long enough to reach from the axilla to six inches beyond the foot; through its upper end are two holes, and its lower end is cut into a three-pronged-like fork. This is rolled up in a sheet, so folded that it will reach from the tuber ischii to the malleoli, thus leaving the last six inches of the splint bare; enough of the sheet must be left free to surround both limb and splint afterwards. The splint is then laid along the injured side with the free part of the sheet under the limb. The "perineal band" is next placed in position, but left slack; this consists of a padded handkerchief, or one covered with gutta-percha, passing under the perineum and tied

Fig. 100.

LISTON'S LONG SPLINT.



Observe, that to lengthen the limb we must tighten the *perineal band*, which then forces down the long splint. If the *handkerchief at the foot* is tightened, the splint is pushed up and the limb shortened.

through the holes in the upper end of the splint. The foot should now be fixed to the lower end of the splint by passing a padded handkerchief in a figure-of-eight round the ankle and foot, twisting the ends round each other in front of the sole, and then tying them to the horns of the splint; the objection to this plan is that it is apt to cause pressure on the instep or ankle, and cause eversion of the foot, as the pull is oblique—this last might be remedied by fastening a little square of wood to the splint in front of the sole round which the handkerchief could be brought (Fig. 100). To avoid these defects the late Professor SPENCE used plasters applied to the limb, as in the weight and pulley method, and attached to a

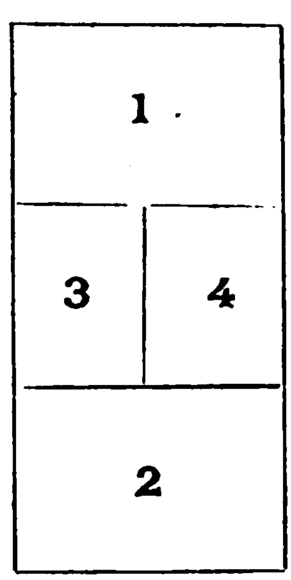
square foot-piece, and then the foot-piece fastened to the horns of the splint; in this way all pressure is avoided on the instep and ankle, and extension secured in a straight line, thus avoiding eversion of the foot. Thick pads of boracic lint are then to be placed along the side, and "bird-nest" pads applied over all prominent points, as the hip, knee, and malleoli. Then bring the free end of the sheet round over the limb, and fasten tightly to the folds of sheet round the splint, by means of long pins, thrust *vertically* across the line of the splint; the pins should be made of steel, spring-tempered, otherwise they are apt to snap, and should have *large* round heads. The upper end of the splint is now to be fastened to the trunk by means of a broad flannel bandage, or kitchen roller, folded once or twice. The foot having been already secured to the horns of the splint, finally make extension by *pulling on the perineal band* and fastening it tightly to the two holes in the upper end of the splint. This is the most important part of the whole apparatus; by pulling on the perineal band the splint is forced downwards, and with it the leg, as the foot is firmly fastened to the splint. On the other hand, should we try to extend by tightening the handkerchief or tapes at the foot, the splint is forced upwards, and with it the lower fragment of the femur. It is very tempting, indeed, to have a pull at the handkerchief at the foot; and, as a rule, nine students out of every ten will tell you that this is how the limb is to be lengthened. The above is all that is required in fracture of the necks of the femur. But in **fractures of the shaft** we require, in addition, padded GOOCH splints; in fractures of the *upper* and *lower* parts of the shaft, the splints must be antero-posterior; in fractures through the middle part of the bone, the splints should be lateral. The splints are fastened by slip-knots, which must be tied over the *inner side* or *front* of the thigh; because if tied on the outer side they could not be tightened or loosened without undoing the whole apparatus. Some use a continuous roller to fasten the splint instead of the sheet, but it is better not to do so, because the fracture cannot be seen without undoing the whole bandage, thus causing unnecessary trouble and pain, and disturbing the fractured bone. There is no objection to using a "many-tailed" bandage (*"a Scultetus"*), but the sheet, used as above directed, is better than anything else.

2. **By Weight and Pulley.**—For this purpose we require two isosceles triangles of strong sticking-plaster with the selvage removed, each long enough to reach from the malleoli to below the seat of the fracture, or to the middle of the thigh in fractures of the upper part of the femur, or in hip joint disease. In cutting the plasters they should always be cut *across the web*—*i.e.*, the way in which it tears most easily—and not along it; otherwise the apices of the plasters will not be able to bear the strain. If in doubt as to the proper way, cut a short strip from both directions and try the effect of pulling on them. The difficulty in many cases will be to find a web *broad* enough for the purpose. The bases are split into three tails, and pieces of strong tape are stitched to the apices. The first thing to be done is to shave the leg, if necessary, and then to pad the heel and the malleoli well and bandage the foot and ankle by figures-of-eight in the usual manner, covering the malleoli well; also place a layer of boracic lint over the sides of the knee under the plasters. Now apply the plasters, bandaging the leg and thigh over them, placing plenty of padding around the knee; this is to be continued till the base of the plasters is almost reached, when all or one (the central) of the tails must be turned down over the bandage, and then the bandage continued upwards over the others, and downwards again as far as may be deemed necessary. In applying this bandage avoid creases and reverses, and leave the plasters for an hour or so to become firm before applying the weight. The tapes at the apices of the plasters are next passed through buckles attached to the sides of a square piece of wood, slightly broader than the sole of the foot. Through the hole in the centre of this piece pass the end of the cord that supports the weight and secure it there, either by simply knotting it, or by a little bar of wood. The pole bearing the pulley is then to be fastened to the end of the bed in some way so as to project from it at an acute angle, and directly in a line with the broken limb. Raise the lower end of the bed and place two blocks, about nine inches high, under its feet; this transforms it into an inclined plane, and a part of the weight of the patient's body acts as the counter-extending force, and obviates the necessity for the irksome perineal band. The weight is now attached to the cord, and the cord placed over the pulley, and the extension is completed. A sand-bag is to be placed

on each side of the limb to prevent eversion, and the whole protected by a wire cage. This is all that is required in fracture of the neck; but in fractures of the shaft we require, as usual, padded GOOCH splints to prevent antero-posterior or lateral displacements. At first a weight of from 12 ℔ to 15 ℔ is usually sufficient, and this at the end of a fortnight or three weeks may be slowly decreased, but carefully watching for shortening in the meantime. It is better in the first instance to make the fractured limb fully half-an-inch longer than the sound one, to allow for the yielding of the knee and ankle joints. In the case of *transverse* fractures, the weight is not so great a necessity; but as fractures of the shaft are usually oblique, it is a most important means of treatment. Another important point is to have a *firm* mattress below the patient; it should be divided transversely into thirds, and the middle third should be divided in the middle vertically, so that one-half can be pulled out for the use of the bed-pan, without raising the patient or disturbing the fracture. Thus:—

Fig. 101.

DIAGRAM OF MATTRESS.



No. 3 is pulled out and No. 4 pushed a little outwards, or also pulled out, and then the bed-pan can easily be placed in position.

The use of sand-bags, however, is troublesome, and the long splint is now generally used instead, with some special foot-piece to prevent it from tilting. In every case Professor CHIENE uses a *double* long splint for the same purpose, with the most satisfactory results. The patient can absolutely move nothing except his head

and his arms; this, of course, gives the fracture the very best possible chance to unite. The splints may be fastened to the limb by ordinary roller bandages, but the sheet is much better. The limb must be kept in this position for six or eight weeks, and after that encased in a starch, or plaster of Paris bandage. The patient may then be allowed to go about on crutches, either with the injured limb slung to the neck, or else the sole of the sound foot raised so that the injured limb may hang free.

In out-of-the-way places it may not be always possible to procure at once the proper weight and pulley; but an ordinary cotton reel, with a strong steel knitting-needle for an axle, a pail containing water for the weight, will form very efficient substitutes. Remember that "a pint of water, weighs a pound and a qua'ter."

3. M'Intyre's Splint as Modified by Liston.—Although the great majority of fractures of the femur are best treated in the straight position of the limb, in some *rare* cases it has been found that the fragments could only be kept in position by flexing the leg and thigh, *e.g.*, in fractures of the shaft just below the lesser trochanter, and again, just above the condyles. This method is advised in cases of transverse fracture immediately above the condyles, where the upper end of the lower fragment is tilted directly backwards by the gastrocnemius, plantaris, and popliteus muscles; hence, when the leg is fixed up in the extended position, the knee joint is really flexed, and the result is either non-union, or union in a useless position. It is for cases such as these that Bryant recommends *division of the tendo achillis* before putting the limb up in the straight position, in cases where the double inclined plane fails to remove the deformity. The splint used for this purpose is M'Intyre's splint as modified by Liston. I subjoin a short description of the splint and its mode of application. It has also been used in cases where, in the straight position, the sharp end of the bone threatens to come through the skin; and in certain fractures of the leg, especially when compound or comminuted. In this splint the weight of the body acts as the counter-extending power. The splint, then, is a double inclined plane with a moveable joint at the knee, and a foot-piece; the foot-piece is fixed in a slot, so that it may be drawn forwards if desired, and its angle *to the axis* of the splint can be shifted by means of a screw. The

angle at the knee can be altered in like manner. At the lower end there is a piece cut away, opposite the heel and tendo achillis, to prevent undue pressure.

In applying this splint, the first thing to be done is to fasten a strip of bandage or a handkerchief across the space at the lower end to prevent the heel falling backwards through the gap. The splint must now be *very well* padded, so that the limb may rest *on* rather than *in* it; but the foot piece must be padded separately. The limb is now laid on the splint, and the foot fixed to the foot piece by a handkerchief or roller bandage passed behind the splint at the heel, then, making a figure-of-eight round the ankle and foot, the ends being fastened to a button on the sole of the foot-piece. The foot-piece is then to be screwed to a *right angle*, and the limb fastened to the splint by *interrupted* circles of broad bandage or plaster. If a continuous roller is used, then we cannot examine the fracture without undoing the whole bandage. Screw the knee into such a position that the fractured ends are in apposition—in fracture at the lower end of the femur this will be nearly a right angle. Cover up the screw behind the knee joint, lest the patient meddle with it, and change the angle into a less irksome position, and swing the limb, splint and all, or else fasten the iron bar behind the heel firmly to a wooden block, so as to get the required height, and also for the purpose of steadying the splint. This splint is also used by some in fracture of the bones of the leg.

For Children.—(1) **The Double Long Splint** may be used, connected at the bottom by a transverse bar; this is necessary because of the restlessness of the patient. The two splints should be wider apart at their lower ends, and not parallel with each other, for the use of the bed-pan. (2) BRYANT'S method of **Vertical Suspension** of the broken limb. A posterior splint is applied from the heel to the nates, and short splints on the sides and front of the thigh, strapping having been previously attached to the leg for the purposes of extension. The limb is then slung up to a hook in the ceiling, or some other convenient point, so as to keep the limb at right angles to the body. By this means the bandages are kept clean, and the weight of the body acts as a constant counter-extending force; one or both legs may be so placed.

THE PATELLA.

This is merely a sesamoid bone developed in the tendon of the quadriceps extensor. It has one centre which appears about the second year, and is fully ossified about puberty. There are two **varieties** of fracture—(1) Transverse; (2) stellate, Y-shaped, or some other form, but not transverse. It may be broken by *direct* violence when the knee is flexed, and the fracture may then be comminuted, transverse, vertical, stellate, etc. The usual cause of fracture, however, is muscular action, as when the patient slips backwards, and, to save himself from falling, throws the quadriceps suddenly into action, when the patella snaps in the same way that a stick is broken across the knee; the patient falls down *because* the patella is broken; it is not the fall that breaks it. The fracture resulting from muscular action is always transverse, and in all probability *always* into the knee joint and also into the prepatellar bursa, unless the fracture merely involves the peak below the articular surface. For this reason the joint swells up from the effusion of blood into it, which, however, usually subsides after a few days' rest. When due to direct violence, the fracture is very often starred or vertical, and then bony union, it is said, is common enough, as the aponeurotic covering is not ruptured; but when due to muscular action, the fragments are often widely separated on account of rupture of the fibrous expansion at the sides of the bone, and the union is usually by fibrous tissue only.

Treatment.—At first, in almost all cases, as there is severe inflammation and great effusion into the joint, rest in the easiest position, and evaporating lotions are indicated, or removal of the fluid by antiseptic aspiration. Whatever method of treatment is adopted, the patient must be semi-recumbent in all cases, with the foot raised to relax the muscles that displace the upper fragment—the quadriceps extensor, but especially that part of it formed by the rectus femoris; after this, the fragment may be brought down by some special appliance. As the upper fragment is chiefly displaced, the special treatment should be brought to bear on it alone without any circular constriction of the joint. Whatever plan be adopted it must be kept up for six or eight weeks at least, and better still, for three months; and after that the limb may be

encased in plaster of Paris, or else the patient must constantly wear a posterior straight leather splint, so as to prevent the joint from being bent for at least three months more, else the fibrous uniting medium will stretch unduly. Many Surgeons believe that the best results are obtained by cutting down on the patella by a vertical incision, and pulling the fragments together by wire or catgut. The objection to this plan is that it opens into the knee joint. It is, no doubt, better for osseous union, but more dangerous, as regards the life of the patient, than the other method.

1. **By Posterior Inclined Plane.**—This is a straight wooden splint with or without a foot-piece, with notches or hooks opposite the knee joint to give a fixed point from which to pull on the patella. The splint is well padded, its lower end well raised, and then the limb placed upon it and bandaged to it from the foot upwards. When the knee is reached take two or three figures-of-eight from the notches on the side of the splint above and below the patella, gradually pressing the fragments together. If there is much swelling and effusion into the joint do not forcibly drag the broken parts together, but first wait till the effusion has subsided. The thigh is then bandaged to the splint, and lastly the foot raised and swung. It will probably be found more convenient to fix the leg and thigh to the splint first and then to use a separate bandage at the knee joint, as this can then be tightened from time to time without disturbing the rest of the splint. The objection to this plan is that the vessels supplying the fractured patella are compressed and the fragments starved.

2. **By Malgaigne's Hooks.**—Two pairs of steel hooks, of which the pair next the skin work in a slot in the other pair, and which can be screwed together or loosened by a screw and nut arrangement, worked by means of a handle. They may be used as MALGAIGNE himself used them, simply passing them through the skin into the broken fragments, only with strict antiseptic precautions; or they may be used in the way practised by the late Professor SPENCE:—Two large pieces of stout plaster, each seven inches long by five broad, with a semi-circular piece cut out of the upper and lower ends respectively, are prepared; also a number of smaller rectangular pieces three inches by two. The posterior inclined plane is applied as before described, and the leg and thigh

bandaged to it. Then stretch the skin and apply the long pieces of plaster so that the notches fit round the edges of the patella; the smaller pieces are next fastened on to the front of these. The points of the hooks are then stuck into these smaller pieces and screwed to the required tightness. In this plan there is no circular constriction of the limb; it was spoken of very highly by the late Professor SPENCE.

3. **Manning's Splint.**—This splint acts on the upper fragment of the fractured patella by elastic, and therefore constant traction, and, at the same time, avoids circular constriction of the limb, so that the articular arteries are not compressed. It consists of a wooden back-piece, a little wider than the knee joint, and long enough to reach from the sole of the foot to the gluteal fold, and provided at the lower end with a foot-piece. At the junction of the middle and lower thirds is a transverse oblique slit one and a half inches long. Strips of strong plaster, two inches broad, and long enough to encircle the thigh and overlap by some inches, are attached to a calico band. The free end of this band is carried through the slit, and the strips of plaster are open on the upper part of the splint. A piece of wood is attached to the lower part of the splint, and another piece of corresponding size is attached to a loop at the end of the calico band, so that, when drawn down and the splint adjusted, these pieces may be five or six inches apart. The foot and the leg having been previously bandaged as far as the lower edge of the patella, and the splint padded so as to leave the slit uncovered, the strapping is heated by means of a bottle of hot water, and, while an assistant draws down the upper fragment by grasping the muscles of the thigh, the strips of plaster are carried firmly round the limb from above downwards, extending from just below the gluteal fold to within three inches of the upper border of the patella. It being important that the band of calico should be kept in the middle line, the upper part of the thigh is then secured to the splint by a few turns of a roller. Lastly, elastic rings are passed over the projecting ends of the pieces of wood, on each side of the splint, so as to exercise sufficient traction on the muscles pulling on the upper fragment and approximate the fragments. In the drawing given in ERICHSEN'S "Surgery," the limb appears to be lying flat; if this is the case a better plan, we

think, would be the usual position for fractured patella—the heel raised some distance above the level of the buttocks.

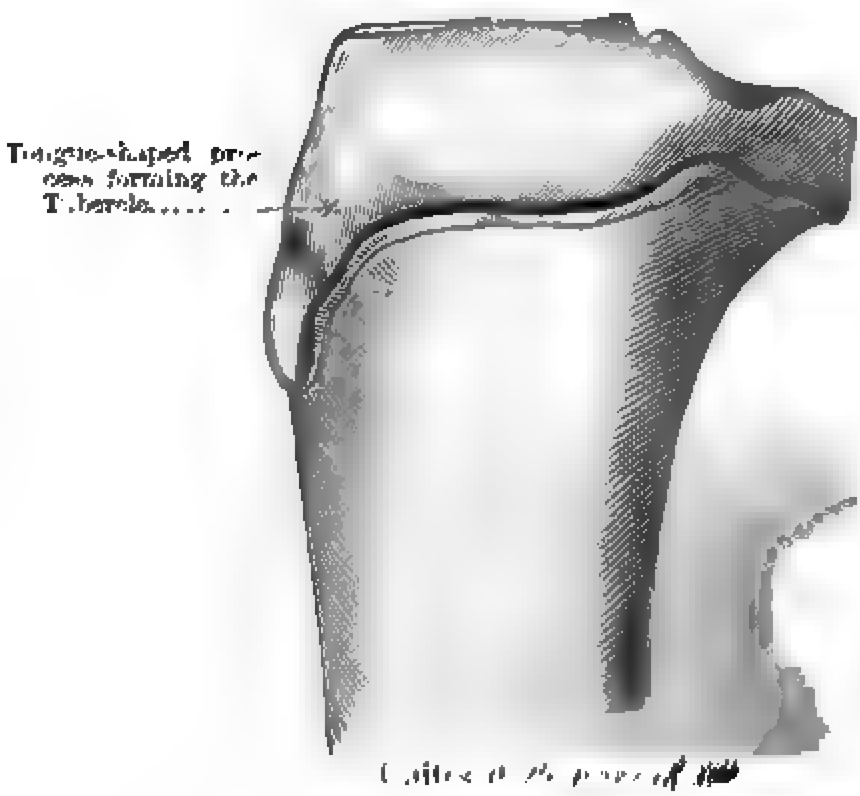
4. The plan adopted at the Middlesex Hospital seems to be a good one. A broad piece of plaster cut out at one border somewhat horse-shoe-shaped, but with the ends of the curve prolonged, is fixed to the thigh, so that the curved edge is level with the normal position of the patella, and is fixed by a few turns of a roller bandage. The limb is now placed on the posterior inclined plane, with foot-piece, or a M'INTYRE's splint. The lower fragment is fixed by means of a pad of lint and plaster bandage. To the ends of the plaster, tapes are stitched, which are attached to india-rubber "accumulators," which are in turn fastened by means of strips of bandage to the foot-board of the splint. The requisite amount of tension is obtained by loosening or tightening these strips of bandage.

THE BONES OF THE LEG.

Like the bones of the fore-arm, both these bones are developed from three centres, that for the shafts appearing about the [illegible]

Fig. 102.

HEAD OF TIBIA.



time. The centre for the head of the tibia appears at the time of birth, and that for the fibula about the fourth year; both join their

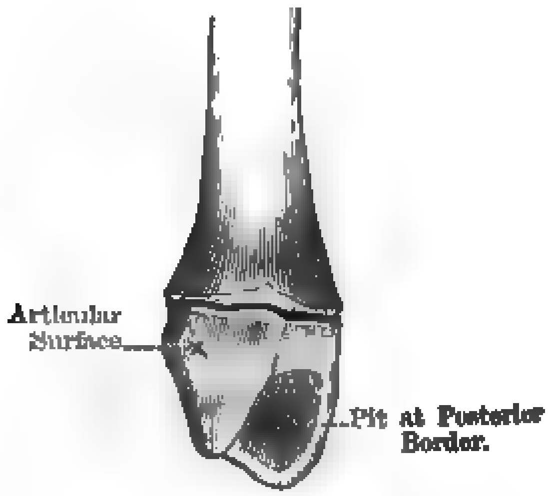
Fig. 103.
Lower End of Tibia.

Unites at 20 years of age.

Fig. 104.
Upper End of Fibula.

Unites at 25 years of age.

Fig. 105.
Lower End of Fibula.



Unites at 20 years of age.

respective shafts at twenty-five (Figs. 102, 104). The centres for the lower ends of both appear during the second year, and join the shaft at twenty (Figs. 103, 105). It will be noticed, therefore,

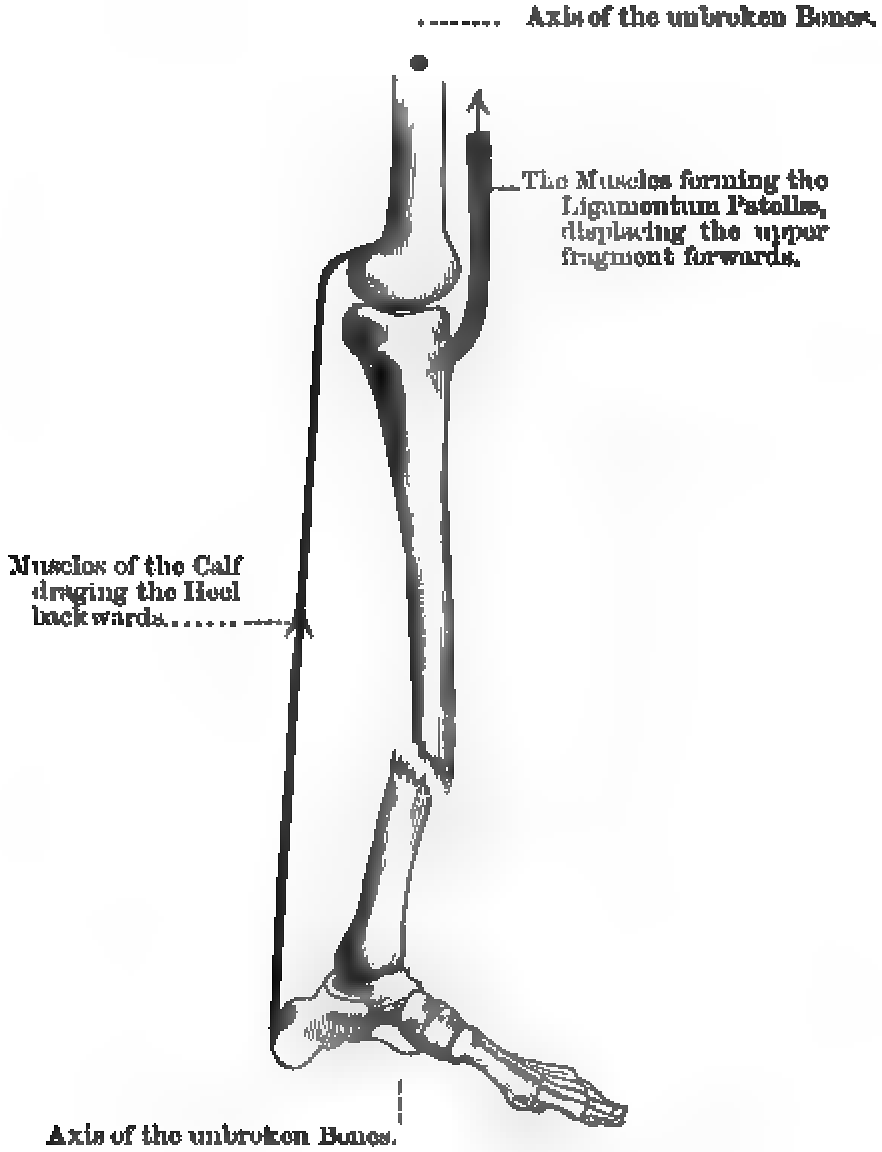
that, opposed to the usual custom, the lower epiphysis of the fibula appears first and unites first. The tibia grows in length chiefly from the upper epiphysis. This epiphysis includes the facet for the fibula on the outer side, and the groove for the semi-membranosus on the outer side; in front it slopes down obliquely so as to include the whole of the "tubercle" of the tibia, the insertion of the ligamentum patellæ (Fig. 102). The lower epiphysis of the tibia has no muscles attached to it, but includes the inner malleolus and the facet for the fibula.

The fibula is surrounded by a thick pad of muscles for the greater part of its extent, which thus gives an otherwise weak bone great support; its lower fourth, however, is subcutaneous. The anterior border and inner surface of the tibia are entirely subcutaneous, hence any irregularity in outline can be readily detected, and for the same reason the fracture is more often compound and comminuted than any other bone; it becomes compound in two ways—either from the force that breaks the bone in *direct* violence, or else from a sharp fragment being forced through the skin in *indirect* violence. Each of the bones may be broken separately, but usually both are broken together. If the tibia alone be broken, or if the fibula alone be broken, there is usually little displacement, because the sound bone acts as a splint to the fractured one, and especially if the fracture be transverse. The weakest part of the shaft of the tibia is about its lower third, and the weakest part of the shaft of the fibula is about its upper fourth, and at these points, therefore, the bones usually give way in fracture from *indirect* violence; the fracture, further, is usually oblique from behind, downwards, forwards, and a little inwards. In *direct* violence the fracture will be transverse and at the point struck. In *transverse* fractures of one bone there will be little displacement, muscular action simply keeping the fractured ends in apposition; if, however, the fracture be oblique and both bones broken, the lower fragment is drawn upwards and backwards by the muscles of the calf (gastrocnemius, plantaris, and soleus), and this is more marked if the fracture be situated at the lower part of the shafts of the tibia and fibula (Fig. 106), and rotated outwards by the weight of the foot; while the upper fragment is tilted forwards by the *tendo patellæ* (the tendon of insertion of the quadriceps extensor

cruris—the rectus, the two vasti, and crureus)—and rotated inwards by the sartorius, gracilis, and semi-tendinosus; and this displacement of the upper fragment is more evident if the fracture be at the upper part of the shaft of the tibia. All fractures of the bones of the leg occur with extreme rarity in infancy and childhood.

Fig. 106.

Fracture at Lower Part of Leg.



Tibia Alone.—This is usually the result of direct violence, as a kick or a blow. In transverse fracture, when the fibula is intact, the fracture may be missed unless great care be exercised, as there is no displacement, and the patient may be able to walk wonderfully well. But the existence of a *tender spot* at the seat of the

crack, and the fact that firm *indirect* pressure on the bone above and below this point will probably produce a yielding and crepitus, and certainly cause pain at the seat of the fracture, should prevent any mistake in the diagnosis.

Fibula Alone.—This bone may be broken either by direct or indirect violence. The usual seat is from two to five inches above the malleolus, especially if caused by indirect violence. It may be caused by a twist of the foot, either outwards or inwards, and is then very often associated with partial or complete dislocation of the ankle joint; but in that due to inversion of the foot there is often no displacement at all. If due to eversion, the broken ends of the fibula are driven inwards towards the tibia (see "Dislocations of the Ankle—Pott's Fracture"). There is also a fracture of the fibula occasionally met with, through or just above the malleolus, caused by direct violence, where there is also an absence of displacement. Here again, in diagnosing such fractures, the great guides must be the existence of a tender spot, sharply defined (differing therefore from a bruise or sprain, though both may be present), and the indirect method of pressure applied to the upper part of the fibula, pressing it towards the tibia, when pain will be caused at the fractured spot. If it be merely a bruise, there will be no pain as thus tested. The only source of fallacy in this test is the possibility that the lower tibio-fibular articulation be inflamed, and when pressure is made upon the upper part of the fibula, the pain might be due to squeezing the inflamed articulation, and not to a fracture.

Both Bones.—This fracture may be caused by direct violence, as kicks, blows, wheels passing over the limb, etc., when the bones give way at the point struck; or indirect violence, such as jumping from a height, severe twists, etc., when the bones yield at their weakest parts. The limb is usually everted from the weight of the limb, from the force breaking the bones, and probably also from muscular action. Both bones of the leg require about eight weeks to unite firmly; the tibia alone requires seven, and the fibula alone six.

Treatment. — In cases of fracture of the shaft of a single bone, with little or no displacement, any simple apparatus will be sufficient, such as Cline's side splints, for the first few days, till the swelling has subsided, when the limb may be encased in a starched

bandage, the Bavarian plaster splint, CROFT's dressing, or it may be treated by the "Edinburgh box splint" (SPENCE's), to be described immediately. The chief objection to all immovable dressings is that the fracture cannot be examined from time to time to correct any possible error of position. When **both bones** are fractured, or, indeed, in any form of fracture, the most simple and convenient splint to use, and one by which perfect apposition can be secured, is that known as—

The "Edinburgh Box Splint."—This consists of—(1) Two narrow pieces of board, long enough to reach from the knee to a few inches beyond the sole, so that when applied they should command both knee and ankle joints, and broad enough to prevent the slip-knots pressing on the leg; (2) a sheet folded a little shorter than the length of the splints; and (3) two small towels to form pads for the front of the limb. In addition to this we require slip-knots, roller bandages, padding, etc.

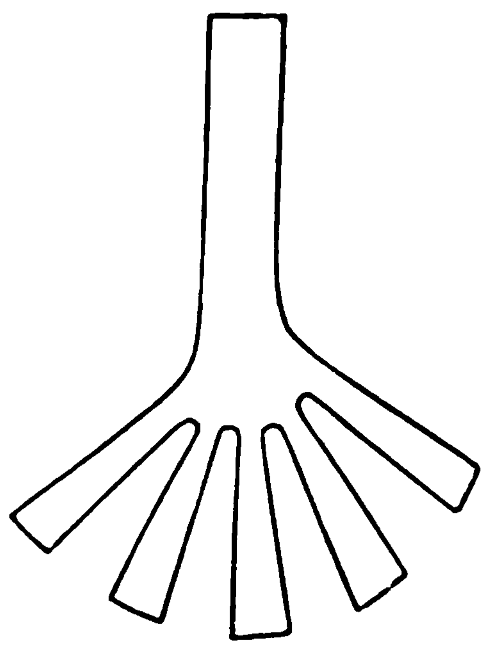
In applying this apparatus, roll up the splints from different sides of the sheet till there is just enough room left for the leg. We have thus a "box," the sides of which are formed by the splints covered by the sheet, the posterior part of the box simply consisting of several layers of the folded sheet. If desired, this may be rendered rigid by introducing a strip of pasteboard between the layers of the sheet. Now bend the knee, and lay the leg in the box thus made, taking care to pad the prominences about the knee and the malleoli well. If preferred, the leg may be laid on the middle of the sheet in the first instance, and the splints rolled up from either side; this will obviate the necessity of lifting the leg afterwards. The foot is then to be fastened at *right angles to the leg* by a few turns of a figure-of-eight round the ankle and splint—the bandage being carried from the inner to the outer side of the foot across the dorsum, so as to guard against any possible eversion; then lay the towel pads on the front, so as to overlap at the fractured part, after which secure the splint to the leg by slip-knots, one of which is to be carried over the double pad of towel in the region of the fracture. If *one* towel only be used, then the fracture cannot be examined without undoing all the slip-knots; whereas, if *two* be used, as described above, by simply undoing the central slip-knot, the ends of the towels can be turned

back, and the fracture examined without slackening the rest of the dressing. By this plan the fractured point can be examined very easily without disturbing the rest of the splint, which could not be done were an ordinary roller bandage used; all that is required in this case is simply to undo the middle slip-knot and turn back the ends of the two towels. The limb is now to be laid on a couple of pillows, or swung, with the knee considerably bent, to relax the muscles of the calf. The fracture can be examined from time to time without disturbing the limb. The most important points to be kept in mind are—(1) To keep the foot at right angles to the leg; and (2) to guard specially against any eversion of the foot—a little inversion is not so objectionable, although this should also be avoided. Both these conditions can be readily carried out by using the "box splint." To keep the foot at right angles a figure-of-eight of elastic, or ordinary domett bandage, is passed round the foot and fastened to the sides of the box. To judge whether the foot is properly placed as regards eversion and inversion, it should be noted that when the foot is in the proper position *the ball of the great toe, the internal malleolus, and the inner edge of the patella, are all in one vertical plane, and the patella looking directly upwards.* Even in health, however, there is a slight tendency to inversion of the foot. In methods of treating these fractures, where the knee joint is flexed and the leg laid on its outer side on a pillow, it is impossible to judge of the eversion and inversion; hence the usual result is that the patient rises with the foot very much everted, the toes probably pointed, and consequently a crippled and useless foot—a condition not only bad at the time, but one likely to induce disagreeable secondary consequences, *e.g.*, flat-foot, with all its aches and pains. In cases where the fracture is very oblique, and accompanied with much shortening, it will be necessary to employ the weight and pulley. In cases where the fracture is low down, there may not be sufficient room to apply the extension plasters, but a short elastic sock, laced to the foot should be used, with side straps to fasten to the buckles on the square of wood to which the cord is attached. We may also use two pieces of plaster cut into a number of short tails, to grasp the dorsum of the foot, and the sides and posterior aspect of the heel, as shown in Fig. 107. The

"box splint" may be used in almost *every* case of fracture of the bones of the leg, even for fracture low down, where the chief difficulties are, the eversion of the foot and the drawing back of the heel (see Fig. 106), although special splints have been devised for both these displacements—DUPUYTREN'S splint for the eversion, *e.g.*, in "POTT'S fracture;" and the "stirrup splint" (SYME), for the falling back of the heel.

Fig. 107.

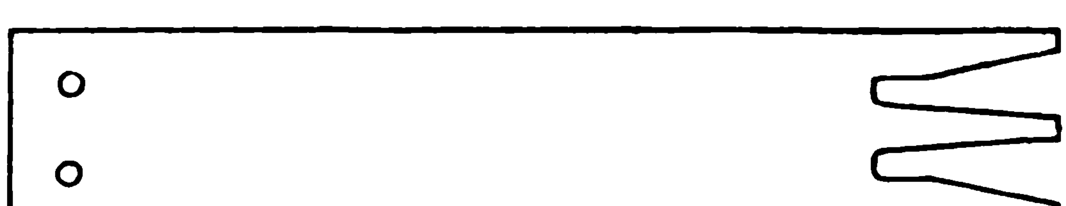
EXTENSION PLASTER.



Dupuytren's Splint.—This may occasionally be useful in "POTT'S" fracture. It is a most troublesome splint to apply properly, and equally difficult to keep in proper position when it is applied, as it always tends to shift; if it is to be used the

Fig. 108.

DUPUYTREN'S SPLINT.



(The "Short, Long Splint.")

knee must be flexed and the limb laid on its inner side on a pillow, and not swung. Further, the same objection may be urged against it as against the special splints used for COLLES'S fracture; it causes excessive inversion, thus *displacing* the foot

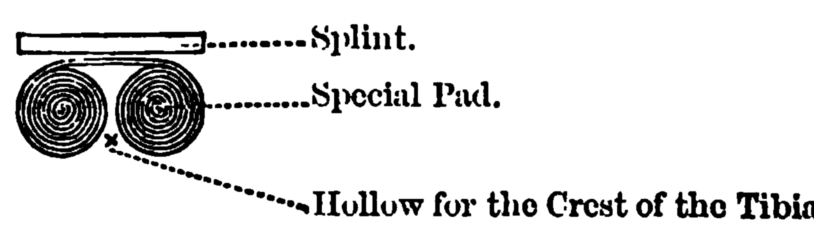
as far in the opposite direction as the injury did in the other. It consists (1) of a tri-furcated wooden splint, with two holes at its upper end, long enough to reach from the *head of the tibia* to four or five inches beyond the sole (Fig. 108). (2) A pad of towel or sheet the width of the splint, and doubled on itself at its lower end.

Fasten the split ends of a roller bandage through the holes at its upper end, as this will steady the splint and prevent it from being forced upwards. Apply the pad over the splint, so that the doubled end of the towel may be over the internal malleolus, forming a soft fulcrum round which the foot is to be inverted; fasten it to the splint by slip knots or a continuous bandage. As the object is to invert the foot and throw the broken ends of the fibula outwards, the splint, thus prepared, is applied along the inner side of the limb on the same lie as the bones of the leg, and secured firmly to the head and upper part of the tibia, but not carrying the bandage above the knee joint, as the knee has to be flexed. The knee must be bent so as to relax the muscles of the calf which pull back the heel and point the toes; the foot is then brought to right angles and inverted. At the lower part of the leg, the bandage securing the splint to the leg and inverting the foot, must not go above the external malleolus, otherwise it will press the broken ends of the fibula towards the tibia. The splint is firmly fastened to the leg at the lower end, and the foot is then to be inverted to the desired extent by means of a few properly applied figure-of-eight turns of a bandage; the figures-of-eight must be led round from the inner side and across the dorsum of the foot, and then inwards across the sole, and secured round the prongs of the splint. The part of the foot to be acted upon in producing the inversion is just above the projection of the fifth metatarsal bone, and not on the heel. Lastly, the knee being well flexed, as already indicated, the limb should be laid on its inner side on a pillow, and secured thereto by strips of bandage. In applying this splint, therefore, for Pott's fracture—(1) Mount the splint; (2) lay it along the inner side of the leg; (3) fasten it to the head of the tibia; (4) fasten it to the lower end of the tibia; and (5) invert the foot by figures-of-eight round the horns of the splint and foot.

The "Stirrup Splint" (SYME).—This is a wooden splint with one end like a horse-shoe, and two holes through the upper end; it is mounted in the same way as DUPUYTREN'S splint. A sheet or large towel is also required, rolled up from each side towards the centre, forming a pad very thick at each side but less so in the middle, so that when applied along the front of the sharp edge of the tibia, the splint may rest on the rolled up thick parts of the pad, in this way fulfilling two purposes, first steadying the splint, and secondly protecting the sharp edge of the bone from pressure (Fig. 109). This splint was formerly used to prevent retraction of the heel in fracture of both bones of the leg low down; it may also be used at the same time to overcome excessive inversion or eversion. Like the last splint it is most difficult to fasten on and keep in position; and very often the patient could not bear it, as the soft parts in front are sometimes injured.

Fig. 109.

PAD FOR "HORSE-SHOE" SPLINT.



Fasten a pad, like that used with DUPUYTREN'S splint, firmly to the splint by slip knots, so that the doubled end is level with the middle of the arch of the horse-shoe. Place the special pad along the front of the tibia, and then lay the splint along the front of the tibia with the prongs on either side of the foot. Then a handkerchief, or bandage, is brought under the tip of the heel, neither above nor below that point—if brought in front of the sole it would push the heel backwards, and if applied higher up it would simply cause greater displacement. It is then carried round the shoulders of the prongs, there crossed, and the figure-of-eight completed round splint and ankle, and fastened. The object is simply to *lift up* the heel and hang it to the end of the horse-shoe. Lastly, the upper end of the splint is fastened to the leg by a turn of bandage passed through the two holes there, so that

the splint may not slip; and a strip of bandage is passed from one horn of the splint to the other in front of the foot.

Before the "stirrup splint" came into use, in cases of great retraction of the heel, DUPUYTREN's method was generally adopted, viz., a posterior splint to *push* the heel forwards. A well padded GOOCH splint may be used for this purpose—this keeps the heel in position, and prevents any possible retraction. The pressure on the heel, however, should be made as diffuse as possible in order to prevent ulceration.

I will now give a short **résumé** of the different methods used in the treatment of "POTT's fracture"—which method to choose in any given case will depend much on the special displacement present, the presence and position of blisters, abrasions, or wounds complicating the fracture. Whatever plan is adopted, the first and by far the most important part of the treatment is to put the fractured bones into as good position as possible before applying the splints.

1. The "**Box Splint,**" properly padded to overcome the displacement, *e.g.*, to overcome the eversion, place one special pad just above the internal malleolus, and another over the external malleolus. See that the heel is kept well forward.

2. **Dupuytren's Splint** may be used in cases where the eversion is excessive, and provided there is no wound or blister over the inner aspect of the leg.

3. **Double Poroplastic Splints** moulded to the limb, the bones being first carefully set, and the leg being retained in proper position till the splints become rigid.

4. The "**Stirrup Splint,**" where the backward displacement of the heel is the most marked symptom. Have a specially prepared pad along the crest of the tibia, lest the splint cause ulceration of the soft parts—this method pulls the heel forwards.

5. DUPUYTREN's **Posterior Splint** to push the heel forwards. See that the pressure over the heel is diffused properly, lest a pressure ulcer be formed.

RÉSUMÉ of fractures near the ankle joint:—

1. Fracture of both bones: great trouble by the falling back of the heel.
2. Fracture of the internal malleolus, with rupture of the external lateral ligament; foot displaced inwards.
3. POTT's fracture—fracture of the fibula about an inch and a half or more above the external malleolus, with rupture of the internal lateral ligament, or snapping across of the internal malleolus; foot markedly everted, and heel often much retracted.
4. DUPUYTREN's fracture—fracture of the fibula and rupture of the internal lateral ligament, as in POTT's fracture; but also rupture of the inferior tibio-fibular ligament, or else the part of the tibia to which it is attached is torn off; foot displaced outwards, as a whole, without marked eversion or inversion.
5. Fracture of the fibula in the same position as in POTT's fracture, due to *inversion* of the foot; the fractured ends tilted outwards. In POTT's fracture it is due to *eversion* of the foot, and the broken ends are driven in towards the tibia.
6. Fracture of the fibula, just through the malleolus, from direct violence; little displacement, but foot may be slightly *inverted*. In diagnosing this fracture trust chiefly to the existence of a *tender spot* and pain on indirect pressure—pressure at the upper part of the fibula—and the nature of the violence.

I must be pardoned if I have, for the most part, described the Edinburgh methods of treating fractures. I have done so, not merely because they *are* the Edinburgh methods, but because of their simplicity and efficiency. I do not write this as an apology, because the methods require no apology. The lecturer on Surgery has no right to waste his time teaching the student—who will probably by-and-by drift into general practice in some out of the way place—the use of complicated methods, which it will probably be out of his power then to procure, or his patients to pay for, and which are, for the most part, of advantage only to the instrument

maker. It is better to describe the use and application of simple methods and means—methods that can be applied anywhere, and splints that can be made in a few minutes by any carpenter, or even by the Surgeon himself, if he be at all conversant with the use of such tools as a pair of scissors, a pocket-knife, and saw. The principles I have endeavoured to lay down, and the methods I have described, may be applied with equal facility in the sequestered valleys of Wales, on the hillsides of Scotland, among the ancestral homes of England, in the humble cabins and among the bogholes of Ireland, in the Australian bush, and in the backwoods of the Far West.

CHAPTER XXVI.

EXCISION OF BONES.

THE UPPER JAW.

THE upper jaw articulates with nine bones—viz., the frontal, the ethmoid, the nasal, the malar, the lachrymal, the inferior turbinated, the palate, the vomer, and, lastly, with its fellow of the opposite side. This bone assists in the formation of three *cavities*—the roof of the mouth, the floor and outer wall of the nasal fossæ, and the floor of the orbit; it also helps to form two *fossæ*, the zygomatic and the spheno-maxillary—and two *fissures*, the spheno-maxillary and the pterygo-maxillary. A knowledge of these facts has a most important bearing in the matter of diagnosis. In the case of malignant disease, the bone must only be removed, provided the Surgeon convinces himself that he can remove all the diseased tissue and, at the same time, cut wide of the disease. In examining a tumour of the upper jaw, the Surgeon must look at it from five points of view—(1) From the face, (2) from the orbit, (3) from the nose, (4) from the mouth and pharynx, and (5) from the temporal and zygomatic regions, and then ask himself the questions—(1) Where did it begin? and (2) What are its attachments now? Should it implicate the basi-sphenoid, the frontal or ethmoid cells, as shown by *separation* and divergence of the eyes, and broadening of the root of the nose, it will be better to leave it alone. Among the early signs of malignant tumour of the upper jaw may be noted—(1) Overflow of tears from pressure on the nasal duct; (2) shooting pains in the supra-orbital region from implication of the fifth nerve; and (3) blocking of the nostrils. As in all operations about the mouth, hæmorrhage is one of the chief difficulties and dangers, not merely from the actual loss of blood, but from the danger of *asphyxia from* the blood passing into the pharynx; another very

serious danger, should it reach the lungs, is that it is apt, at a later period, to set up a suppurative form of pneumonia ("Interlobular Suppurative Pneumonia"), probably from the coagulated blood becoming septic and putrifying in the vesicles. This danger, however, is not so great in excision of the upper jaw as in many other operations; still, if great hæmorrhage is expected, some of the following special means may be adopted. The risk of the operation itself is small, and in this respect it contrasts very markedly with excision of the tongue, where the risk is very great and the prognosis grave.

Note on Diagnosis.—If the tumour—*e.g.*, a sarcoma—

1. Begins in the **malar bone,** it pushes the cheek into a conical projection, and bulges into the mouth between the gums and the cheek. The line of the teeth and the palate are normal.
2. If it begins **behind the upper jaw,** it pushes that bone forwards as a whole; the line of the teeth and the antrum are normal.
3. If it begins in the **antrum,** it expands the walls of that cavity, bulging into the nose, mouth, and orbit, and causing a projection on the face. The line of the teeth is also irregular.
4. If it begins in the **ethmoid cells,** it causes broadening of the root of the nose and projection of the eye *outwards*, rather than forwards. There will also, probably, be a history that the swelling began higher up than the antrum. Mere protrusion forwards of one eye is not so bad, but when the eyes are separated it indicates that the growth has either begun in, or spread to, the ethmoidal sinuses, and is, therefore, too far gone for operation.

One plan to obviate the risks from hæmorrhage **is to** source of the blood lower than the opening of the **larynx,** the patient's head to hang over the end of the **table a** out the accumulated blood from time to time (**AN** TRENDELENBURG'S "trachea-tampoon" may **be r** fication of it; or, as MACEWEN suggests, **one**

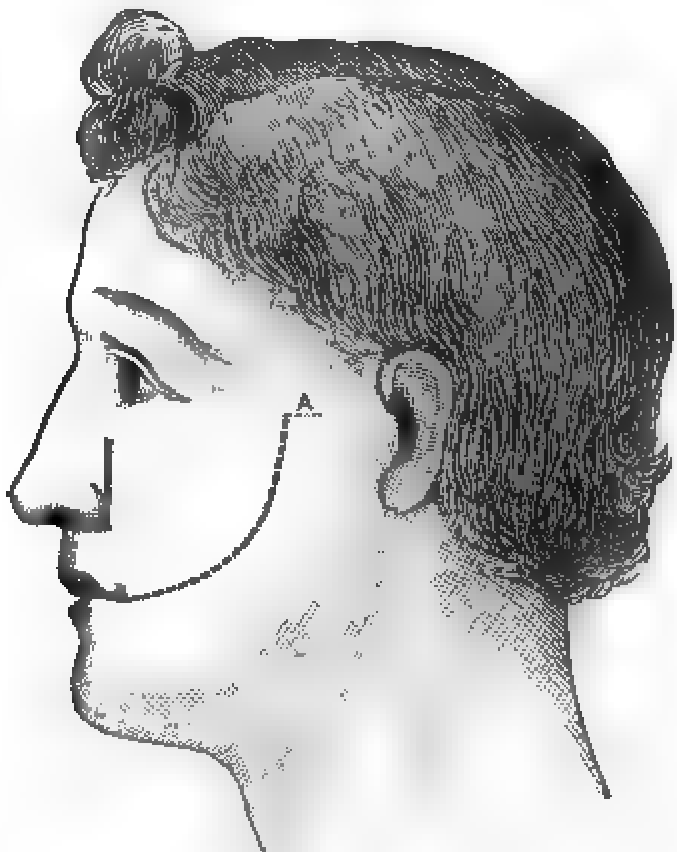
through the glottis, after which the entire pharynx is tightly filled with a sponge; or, a still simpler and more efficient plan, adopted by Professor CHIENE, in cases demanding such severe measures—a preliminary tracheotomy is performed, and the pharynx filled with a sponge, and an elastic tube, passing from the end of an ordinary funnel, is inserted into the inner part of the tracheotomy tube, and through this the patient inhales the chloroform; over the mouth of the funnel a fold of domett bandage is stretched, and on this the chloroform is dropped as required. Besides its simplicity this plan has another advantage—namely, that the chloroformist is well out of the way of the operator.

Instruments required.—The usual instruments required in all major operations, also tooth forceps, a narrow saw with a movable back and a large handle, bone forceps, lion forceps, gouges, hair-lip needle or silver wire suture, retractors, chisel and mallet at hand lest they be required, wire nippers; and perchloride of iron, or the actual cautery for the hæmorrhage; solution of zinc chloride, to touch up doubtful parts afterwards; and lastly, some of the special means for the management of the hæmorrhage, and the administration of chloroform. The **Surgeon** stands on the same side as the bone to be removed in the first instance, but during the sawing of the bony points he will probably find it most convenient to stand *always* on the right side. The usual number of **assistants** may be made use of, and their duties require no special mention. (1) Place the **patient** in a semi-recumbent position, shave the parts if necessary, compress the facial artery as it passes over the lower jaw, extract the central incisor tooth of the diseased side, and then make the **incision**—(*a*) LISTON'S (Fig. 110). Enter the knife opposite the external angular process of the frontal bone (*i.e.*, a little above the zygoma), and carry it in a semi-circular manner downwards and forwards to the angle of the mouth. Another incision is then made from the nasal process of the superior maxillary bone down the side of the nose, round the ala, and through the centre of the upper lip into the mouth; this flap is then dissected upwards and inwards. This is the most convenient incision when the tumour is of large size. (*b*) *By External Flap* (Fig. 111, *a*). Cut horizontally from the outer to the inner canthus of the eye, then straight down to the ala of the nose, round it

and through the centre of the upper lip into the mouth; this flap is then dissected downwards and outwards. The great advantage of this incision is that the arteries and nerves of the face are cut close to their terminations, and not through their larger branches, as they are more likely to be by LISTON'S method. (2) Having divided the mucous membrane and dissected the flap off the jaw, separate

Fig. 110.

LISTON'S EXCISION OF THE UPPER JAW.



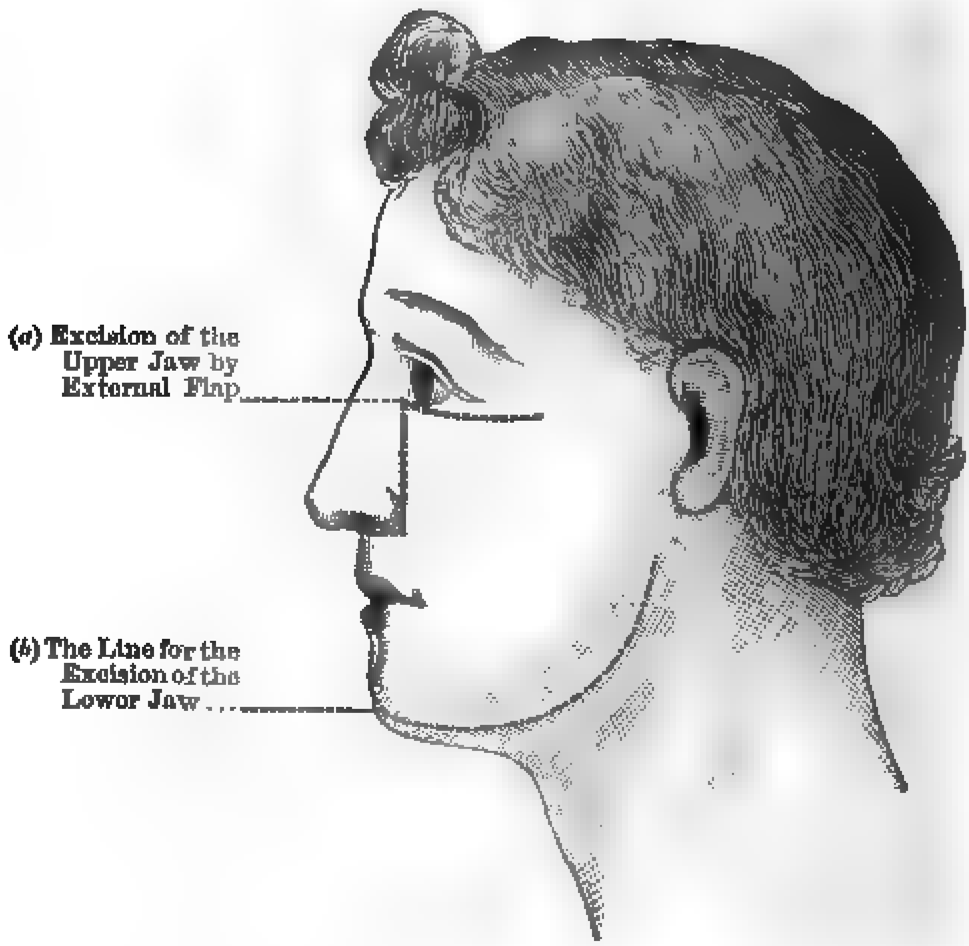
A—Position and direction of the additional incision when the malar bone is to be removed as well.

the soft parts from the floor of the orbit, including the periosteum, and should the case admit of it, the orbital plate of the superior maxilla as well, using a thin copper spatula to protect them and the globe of the eye. Before going any further, it will be well to tie all the bleeding vessels, such as the coronary and angular; after which (3) divide the bony points.

There are four bony attachments to divide. The following order will be found convenient:—(1) The malar attachment; this is first to be deeply notched with the saw, parallel with, and immediately in front of, the masseter muscle, passing into the spheno-maxillary fissure. (2) The palate attachment to the opposite bone and the palate bone; the saw is passed into the nostril, and the hard palate and the alveolus divided. The saw should be kept

Fig. 111.

Excision of the Jaws.



parallel in the nostril, as there is but little danger of injuring the soft palate, as it hangs down perpendicularly from the end of the hard palate. It is useless to attempt to dissect off the soft tissues from the hard palate. (3) The nasal process of the superior maxilla, articulating with the nasal, frontal, and lachrymal; the bone forceps alone is usually sufficient for this purpose, one blade *being placed* in the orbit, the other in the nose, with the *flat* side,

as usual, next the part to be left. If preferred, this process may first be notched with the saw like the other two, or complete division may be accomplished by a chain saw. Some Surgeons divide these points with the saw in the following order:—Palate, nasal, malar, and then complete the division with the bone forceps in the reverse order. The forceps are now used to completely divide the malar attachment, and, lastly, the palate process and alveolus; in dividing this last part the forceps can also be used as a lever to prise the bone from its bed, thus preparing the way for the next part of the operation. Dr DUNCAN completes division of the malar attachment by the bone forceps last of all, as he says it is easier to loosen the bone by working downwards and inwards than by prising it upwards and outwards, as is done when the palate attachment is divided last. (4) Everything being now ready for the gush of blood likely to follow removal of the bone, and the patient brought fully under the influence of the anæsthetic, and the soft palate separated from the hard by a transverse incision, the jaw is firmly grasped with the lion forceps, and with a firm, sudden wrench downwards and outwards the bone is torn from its posterior attachments; in this way its attachments to the palate bone and the pterygoid processes behind, and the ethmoid bone above are torn away. As the bone is wrenched out, any soft tissues must be divided with the fingers or bistoury, such as the origin of the temporal muscle in the zygomatic fossa, the buccinator muscle, and the infra-orbital nerve, etc. When the bone is removed there is great hæmorrhage, and the cavity must be at once packed with a dry antiseptic sponge, or strips of lint, till the vessels (which are mostly of small size) have had a little time to close themselves by retraction and contraction; the vessel that gives most trouble is the posterior palatine artery, which is torn just at the last moment. After this the packing is removed, the vessels tied, and some strips of lint dipped in zinc chloride or iodoform are introduced to support the cheek flap, and which are to be left in for two or three days. Iodoform, or a solution of chloride of zinc, is the most effective antiseptic to use in the first instance, and afterwards continuous irrigation with some warm antiseptic—*e.g.*, boracic acid. The incision must be very neatly and carefully stitched up with horse-hair sutures; these may be used throughout, and will be found

very efficient, but when the lip is reached another plan may be adopted—a hair lip needle passed deeply through the tissues of the lip to act as a splint, or a deep silver suture may be used for the same purpose. *Before* putting in the needle or silver wire, however, a silk suture should be passed through the mucous membrane, but left untied; after this horse-hair sutures are passed and tied to hold the skin edges in apposition, then the silver one is tightened, and, lastly, the silk suture through the mucous membrane is tied, first removing all blood clots from between the edges of the mucous membrane. In this way neat apposition of the cut edge is insured. If the hair lip needle be used, its point must be cut off with the wire nippers. Mr BELL advises that, in making the incision through the skin, we should make plenty of corners and not rounded curves, as the corners act as guides and enable us to stitch like parts to like, whereas, in curves, it is often difficult to tell exactly the corresponding parts of the two sides.

Should it be necessary to remove the malar bone, then from the end of the upper incision carry another cut, one inch in length, along the zygoma (see Fig. 110, A). In this case also it will be necessary to divide the zygomatic process, and the external orbital angle of the frontal bone into the spheno-maxillary fissure by first using a small saw, and then completing the division with the bone forceps. It is better, if possible, however, to preserve the malar bone, as this leaves the prominence of the cheek. In cases also of simple tumour and sarcoma confined to the alveolar edge, leave the orbital plate of the superior maxilla, as this gives support to the eyeball; where this plate is removed the eye falls down and is apt to be destroyed by subsequent inflammation.

Chief Parts Cut Through.—1. The skin and fascia; part of the orbicularis palpebrarum, orbicularis oris, and temporal fascia; part of the masseter and temporal muscles, zygomatici, buccinator, and other muscles of expression; the lachrymal sac or nasal duct, levator labii superioris et alæ nasi, compressor naris, depressor alæ nasi, orbicularis oris, inferior oblique of eye, and tendo-oculi; and the mucous membrane of the lip. 2. **Nerves**—Chiefly branches of facial and branches of second division of the fifth that appear on the face, as well as the infra-trochlear, and in the end the trunk of *the second* division of the fifth itself in front of MECKEL'S ganglion.

3. The various **bony points** already mentioned. In tearing the bone from its posterior attachments, the vertical plate of the palate bone, pterygoid fossa, and internal pterygoid muscle, are usually torn away as well. 4. **Arteries**—(*a*) Branches of the temporal—(1) Orbital; (2) middle temporal; and (3) transverse facial. (*b*) Facial near the angle of the jaw and several of its branches—(1) Superior coronary; (2) lateral nasal; and (3) angular. (*c*) Termination of the internal maxillary artery, probably, and certainly many of its branches—(1) The buccal; (2) posterior dental; (3) infra-orbital; (4) descending palatine; and (5) spheno-palatine. 5. Corresponding veins.

RÉSUMÉ of this operation :—

1. Extract a central incisor tooth.
2. Make the incision through the soft parts.
3. Secure all bleeding points.
4. Raise the flap upwards and outwards, and again secure bleeding points.
5. Separate the soft from the hard palate by a transverse incision; don't bother about the soft covering of the hard palate.
6. Notch the palate process deeply with the saw, and then do the same to the malar junction.
7. With a large bone forceps complete the division of the malar attachment, entirely divide the nasal, and complete the division of the palate process, at the same time giving the bone a prise outwards, using the bone forceps as a lever.
8. With the lion forceps wrench the bone suddenly and forcibly downwards and outwards.
9. Quickly plug the gap thus made to control hæmorrhage.
10. Lastly, carefully stitch up the external wound and lip.

THE LOWER JAW (One-half).

The same principles must guide as in the last operation. If the tumour be a simple one, then keep close to it during the operation; but if, on the other hand, it is malignant, cut wide of it. The **instruments required** are the same as in the previous operation; in cases where a part only of the bone is removed, a match, or

some similar piece of wood, partially sharpened, should always be at hand to plug the foramen in the bone, where the inferior dental artery lies, in order to stop the bleeding. The **Surgeon** stands on the right side. (1) Place the **patient** in a recumbent position, with the shoulders slightly raised; shave the part if necessary, extract an incisor tooth, fix the point of the tongue, and make the **incision** (Fig. 111, *b*). The usual directions are to begin the incision above and immediately behind the articulation of the lower jaw, but in front of the temporal and external carotid arteries, and carry it deeply down to the bone along the ascending ramus of the jaw, and then forwards *under* the horizontal ramus, so that the resulting scar may be hidden, till opposite the point where the bone is to be divided, and then carry it upwards towards, but do not divide the lip. The lip, however, may be divided if necessary, as it really does not matter since it unites readily enough, and the saving of it might embarrass the operator. An important point is to endeavour to have everything separated from the jaw on the outer side and below, and the bone divided before opening through the mucous membrane into the mouth; this will help greatly to prevent blood passing into the trachea. For the same reason it is probably better not to draw a tooth as the *first* step of the operation. In the case of a simple tumour of limited extent; or in the case of a female, an attempt may be made to do the whole operation by an incision under the jaw. Secure the facial artery, before or as soon as divided, by a catch forceps (WELLS's), and at once tie it. (2) Dissect this flap upwards and inwards to expose the bone, and clear the inner side of the jaw from contiguous structures, using a narrow bistoury, and keeping its edge close to the bone. (3) Saw through the jaw partially, close to the symphysis, and complete the division with the bone pliers. (4) Depress the divided ramus with the left hand or lion forceps, till the insertion of the temporal muscle into the coronoid process is seen, and then divide it at its insertion. If this be impossible then snip off the coronoid process in the meantime, and remove it afterwards if necessary. (5) Turn the jaw horizontally outwards, still depressing it, to make the external ligaments of the joint tense, and open the joint *from the front*, and *keep* the edge of the knife close to the bone to avoid wounding the

internal maxillary artery. In depressing the jaw it must not be rotated, lest the artery in this way be stretched round the neck of the bone and be torn or divided. (6) Divide the insertions of the internal and the external pterygoids; evert the bone, and carefully separate all the soft parts from its inner surface, taking care not to injure the submaxillary gland or lingual nerve, and remove it. Secure the bleeding points and close the incision, and drain from the lower and posterior angle.

NOTE.—In making the incision it is better not to carry it too far up behind the ascending ramus (if the jaw can be disarticulated without doing so) lest the trunk of the facial nerve be severed, and the various facial muscles be therefore paralysed (the portio dura—*facial*—being the *motor* nerve of the face), but only curve it slightly over the angle of the jaw, and dissect up *beneath* this flap very close to the bone. If, however, the nerve must be divided, its main branches should be sutured afterwards with fine catgut. In closing the wound it is better to stitch the two edges of the divided mucous membrane together in order to shut the wound off from the cavity of the mouth; but if this cannot be done then a drainage tube must be passed through into the mouth. The wound and lip (if divided) must be sutured in the same way, and the after-treatment conducted on the same principles as in excision of the upper jaw—continuous irrigation with warm antiseptic fluid. In the case of simple tumours, whenever possible, the alveolus should be divided and the lower border of the jaw preserved.

Chief Structures Divided.—(1) Superficial structures, fascia, and platysma. (2) **Muscles**—viz., the masseter, platysma, part of buccinator, insertion of digastric (anterior belly), genio-hyoid, genio-hyo-glossus of the side excised (if the incision be through the symphysis), mylo-hyoid, a few fibres of the superior constrictor of the pharynx, internal and external pterygoids, depressor labii inferioris, temporal, levator menti, and orbicularis oris. (3) Probably a part of parotid gland. (4) The stylo-maxillary ligament. (5) **Nerves**—viz., inferior dental, small twigs of the facial, part of the auriculo-temporal, mylo-hyoid, and masseteric. Care must be taken to preserve the conjoined chorda tympani and lingual from injury. They lie on the internal pterygoid, and are covered by the external pterygoid; the chorda being the nerve of taste to the

anterior two-thirds of the tongue, while the lingual is the nerve of common sensation to the same part. (6) **Arteries**—viz., inferior dental, facial and its submental branch, inferior coronary, inferior labial, mental and masseteric, and other small muscular branches. The internal maxillary may be cut, or even the external carotid near the point where it divides into the temporal and internal maxillary, if the operator be not sufficiently careful.

The care necessary in disarticulating the jaw will at once be evident when one remembers the close relation of various important structures to it—such as the internal maxillary artery, temporo-maxillary vein, auriculo-temporal nerve with the middle meningeal artery between its two heads of origin, and the chorda tympani close to the Glaserian fissure, and the other branches of the third division of the fifth. Avoid also the facial nerve as far as possible, the external carotid artery, and the lingual nerve.

The excision of the *central* part of the lower jaw is always a dangerous operation. There is the risk of suffocation, from the retraction of the hyoid bone and tongue, when the attachments of the mylo-hyoid, genio-hyoid, and genio-hyo-glossi muscles are divided from the bone. To prevent this as far as possible, the tongue must be fixed by a strong ligature passed through its tip, and held well out by an assistant. For the same reason it is better in excision of one side of the lower jaw not to cut through the symphysis exactly, but a little external to it, so as to leave the insertions of the genio-hyoid and the genio-hyo-glossus muscles.

RÉSUMÉ of this operation:—

1. Extract a central incisor tooth.
2. Make the skin incision: do not go too far up lest the facial nerve be unnecessarily divided, or too far back lest the external carotid artery and temporo-facial vein be divided; secure the facial artery before it is divided by a double ligature, also secure its submental branch.
3. Rapidly dissect up the flap and expose the outer surface of the bone, and secure bleeding points.
4. Clear the inner surface of the bone as far as possible, and then

5. Divide it by saw and bone forceps a little to one side of the symphysis.
6. Depress the divided ramus, and divide the attachment of the temporal muscle into the coronoid process—"*the key of the operation.*"
7. Open the joint *from the front*, taking care of the internal maxillary artery and vein and their junction with the temporal vessels; also the auriculo-temporal nerve and the middle meningeal artery.
8. Complete the disarticulation by depressing the jaw and at the same time carrying it horizontally outwards: secure all bleeding vessels and stitch up the external wound, if possible suturing the edges of the mucous membrane together to shut out the saliva.

THE OS CALCIS.

In excising this bone avoid making any incision in the sole. For this purpose the best form of incision to use is the following:—The patient is laid on his face, and a horse-shoe-shaped incision is carried from a point a little in front of the calcaneo-cuboid articulation round the heel and along the side of the foot to a corresponding point on the opposite side. The flap thus outlined is then dissected down over the prominence of the os calcis, keeping the edge of the knife close to the bone, exposing the whole of its under surface. Then a perpendicular incision is made, about two inches long, behind the heel and through the tendo achillis, opening into the former incision; the tendon is then divided, and the flaps dissected up, and the knife passed between the os calcis and the astragalus, and the strong inter-osseous ligament divided; and lastly, its attachment to the cuboid is divided and the bone removed. Great care is necessary in clearing the inner side of the os calcis from the large number of vessels, nerves, and tendons at that side.

Structures Divided.—(1) The skin, superficial and deep fascia, and cutaneous vessels and nerves. (2) **Muscles**—the tendo achillis, extensor brevis digitorum, abductor minimi digiti, flexor brevis digitorum, plantaris, accessorius, abductor hallucis, and the prolongation of tibialis posticus to the lesser process of the os calcis;

some also divide the peroneus longus and brevis. (3) **Arteries**—chiefly malleolar and calcanean twigs. (4) **Ligaments**—the superior calcaneo-cuboid, the internal calcaneo-cuboid, the superior calcaneo-scaphoid, the external calcaneo-astragaloid, the middle fasciculus of the external lateral ligament of the ankle joint, the posterior calcaneo-astragaloid, part of the deltoid ligament, inferior calcaneo-scaphoid, the long and short calcaneo-cuboid ligaments, and lastly, the strong interosseous ligament.

THE ASTRAGALUS.

This bone may be excised by an external incision, similar to that used in excision of the ankle joint, with, if necessary, a short straight incision over the internal malleolus, sufficient to allow division of the internal lateral ligament. Some divide the peroneus brevis and tertius, but it is better not to do so. The steps of the operation resemble closely those of excision of the ankle joint. It is important to clear the bone on all sides before separating the structures on the posterior edge—the flexor longus hallucis tendon, posterior tibial vessels, and posterior tibial nerve.

The various **Ligaments** connecting the bone with its fellows must be divided as they present themselves:—To the bones of the leg, os calcis, and scaphoid—(1) to the *bones of the leg*—the anterior ligament, posterior ligament, and the lateral ligaments of the ankle joint (the middle fasciculus of the external lateral may be saved); (2) with the *scaphoid*—one, the superior astragalo-scaphoid; and (3) with the *os calcis*—the strong interosseous, and external and posterior calcaneo-astragaloid.

THE CLAVICLE.

The more important Relations of this bone are—In **Front**—The skin, superficial fascia, platysma, and descending branches of the supra-clavicular nerves—the sternal, clavicular, and acromial, from the third and fourth cervical,—the deep fascia, and communication from the cephalic to the external jugular vein. **Behind**—(1) *Vessels*—Subclavian vein, internal jugular vein, and probably the junction of these two to form the innominate vein; external jugular vein, internal mammary artery, and supra-scapular artery and vein; the subclavian artery, common carotid artery, and partly

the innominate artery. (2) *Nerves*—the vagus, phrenic, the great cords going to form the brachial plexus, the nerve of Bell, nerve to the subclavius, and cardiac nerves. (3) *Muscles*—sterno-hyoid, sterno-thyroid, omo-hyoid, scalenus anticus; (4) apex of the pleura and lung; (5) thoracic duct; (6) trachea; and (7) the œsophagus. The last two are not exactly behind, but they are not far from the inner end. In excising this bone, an important point is to secure free access. After the bone is exposed, one of three courses may be pursued—(1) to disarticulate at the sternal end, and gradually turn the bone outwards; (2) disarticulate at the acromial end, and turn the bone inwards; or (3) divide the bone with chisel and mallet at some convenient part of its length, if possible so that the outer fragment is the longer, as that end is the most difficult and dangerous to deal with, and remove it in two parts. I have only seen this operation performed once—for malignant disease of the bone; on this occasion Professor CHIENE was the operator. He exposed the clavicle by a free crucial incision, but, according to his custom, made in such a way that the four angles do not all meet at one point. The flaps were then raised, and the bone divided about one inch from its sternal end. Round the inner end of the outer and larger fragment, a strip of bandage was tied, by which the clavicle was gradually raised, as it was freed from its surroundings. The difficult part of the operation was the division of the coraco-clavicular ligament; this he divided by a probe-pointed bistoury, after which the removal of the bone was an easy matter. The inner end was then freed from its attachments, the joint opened, and the bone removed by division of the strong costo-clavicular, or rhomboid ligament. The only vessel of any size cut during the operation was the supra-scapular artery; twigs of the superior thoracic and acromio-thoracic would probably also be divided. In this operation great care is necessary lest any of the large veins be cut; the great risk of this accident would be the entrance of air, and probably fatal syncope on account of the aspirating power of the thorax. The care requisite is all the greater, since the veins are most anterior. The wound is then closed, and drainage secured from the outer angle; this is the deepest part of the wound, and at the bottom lies the third part of the subclavian artery. One must therefore be careful to

avoid pressure on the end of the tube, lest the other end ulcerate into the vessel. The arm must be bound firmly to the side during the after treatment, pretty much in the same way as is done in fracture of the clavicle.

The Structures Divided.—(1) Skin, superficial fascia, platysma, sternal, clavicular, and acromial twigs of supra-clavicular nerve, twigs of acromio-thoracic artery, communication from cephalic vein to external jugular, and deep fascia. (2) **Muscles**—pectoralis major, deltoid, clavicular head of sterno-mastoid, part of the sterno-hyoid, trapezius, and subclavius. (3) **Ligaments**—of the sterno-clavicular articulation, including the rhomboid; of the acromio-clavicular articulation, including the conoid and trapezoid. In this case also the supra-scapular artery, on account of the position and nature of the tumour.

In **injuries** to the clavicle the veins behind it are very apt to suffer as they are most anterior, but the dense costo-coracoid membrane and the subclavius muscle in most cases protect them from all harm. The descending branches of the third and fourth cervical nerves passing over the bone are important, as they may be implicated in bruises or fractures of the clavicle, or be the seat of reflected pains in disease of the upper cervical vertebræ.

THE SCAPULA.

This may be removed by a crucial or ⊣-shaped incision. By the ⊣-incision, an **incision** is made from the acromial end of the clavicle downwards along the axillary border of the scapula to its inferior angle; from the middle and upper third of this incision another is made at right angles, extending to the posterior border of the bone near the root of the spine. The patient is placed in a semi-prone position, and an assistant commands the subclavian artery by digital compression or a padded key. The flaps are then dissected up, and the acromio-clavicular joint opened. The supra-scapular artery is next found (by feeling for the notch in the upper border of the bone and the transverse ligament, *over* which the vessel passes) and secured; then the posterior scapular is looked for under the levator anguli scapulæ, and also secured. The attachments of the posterior border are then divided and the *bone drawn* backwards and outwards; then the muscles attached

to the coracoid process are divided. Next the shoulder joint may be opened by dividing the subscapularis tendon and the other tendons surrounding the neck of the bone. In doing so avoid the trunk of the subscapular artery and the posterior circumflex.

Structures Divided.—(1) Skin, superficial fascia, branches of dorsal nerves, and deep fascia. (2) **Muscles**—the supra-spinatus, infra-spinatus, teres major, teres minor, deltoid, trapezius subscapularis, serratus magnus, the rhomboids—major and minor, levator anguli scapulæ, omo-hyoid, long head of triceps, pectoralis minor, coraco-brachialis, short head of biceps, long head of biceps, and, in some cases, the latissimus dorsi. (3) **Arteries**—the suprascapular, posterior scapular, the acromial branch of thoracic axis, dorsalis scapulæ, and termination of subscapular. (4) **Ligaments**—of the shoulder joint, of the acromio-clavicular joint, also the conoid and trapezoid ligaments.

CHAPTER XXVII.

THE EYE.

THE ORBIT.

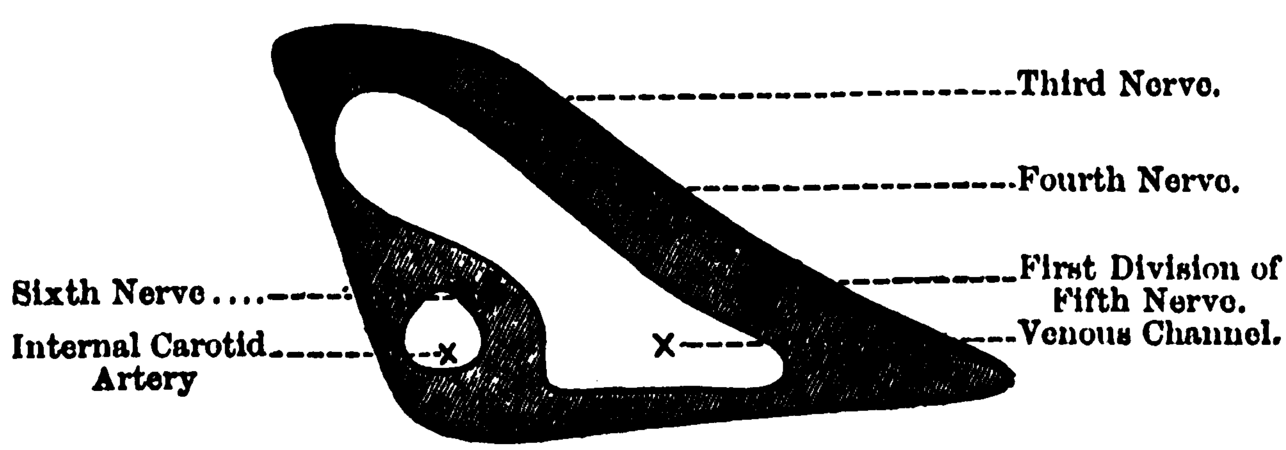
THE cavity of the orbit resembles a four-sided pyramid, the antero-posterior diameter of which is slightly greater than either the vertical or transverse. Its **apex** is formed by the optic foramen; the **base** is surrounded by the frontal, malar, and superior maxillary bones. The **roof** is formed by the frontal bone and lesser wing of the sphenoid; the roof is very thin, and sharp-pointed bodies may easily pass through it accidentally, or be forced through with homicidal intent, and injure the brain. The **floor** is formed by the orbital plate of the superior maxilla, the malar bone, and the orbital surface of the palate bone. On the **inner wall** we find the nasal process of the superior maxilla, the lachrymal bone, the *os planum* of the ethmoid, and the body of the sphenoid. The **outer wall** is formed by the malar bone and the great wing of the sphenoid. The **openings** into the orbit are nine in number:—(1) The optic foramen, which transmits the optic nerve and the ophthalmic artery; (2) sphenoidal fissure (for structures passing through, see after); (3) spheno-maxillary fissure, which transmits the superior maxillary nerve with its orbital branch, the infra-orbital artery, and the ascending branches from MECKEL's ganglion. This fissure opens a communication between three fossæ and the orbital cavity—the temporal, zygomatic, and spheno-maxillary. It will therefore be readily understood how malignant growths can so easily and rapidly spread in both directions—*e.g.*, the rapidly growing forms of sarcomata, which are the tumours most frequently met with in this situation. (4) Supra-orbital foramen, for supra-orbital vessels and nerves; (5) infra-orbital canal, for infra-orbital vessels and nerve; (6) anterior ethmoidal foramen, for nasal nerve

and anterior ethmoidal vessels; (7) posterior ethmoidal foramen, for posterior ethmoidal vessels; (8) malar foramina, for temporal and malar branches of orbital nerve; and (9) the lachrymal groove, for lachrymal sac and nasal duct.

Cavernous Sinus and Sphenoidal Fissure *(foramen lacerum anterius).*—The cavernous sinuses are situated at the sides of the body of the sphenoid bone, and are so named from their presenting a reticulated or cavernous structure. Each sinus begins at the sphenoidal fissure, receiving the ophthalmic vein, and ends at the apex of the petrous portion of the temporal bone by dividing into the superior and inferior petrosals; they are connected by means of the circular sinus, and sometimes also by the transverse sinus. On the *inner* wall of each sinus is found the internal carotid artery,

Fig. 112.

RIGHT CAVERNOUS SINUS.



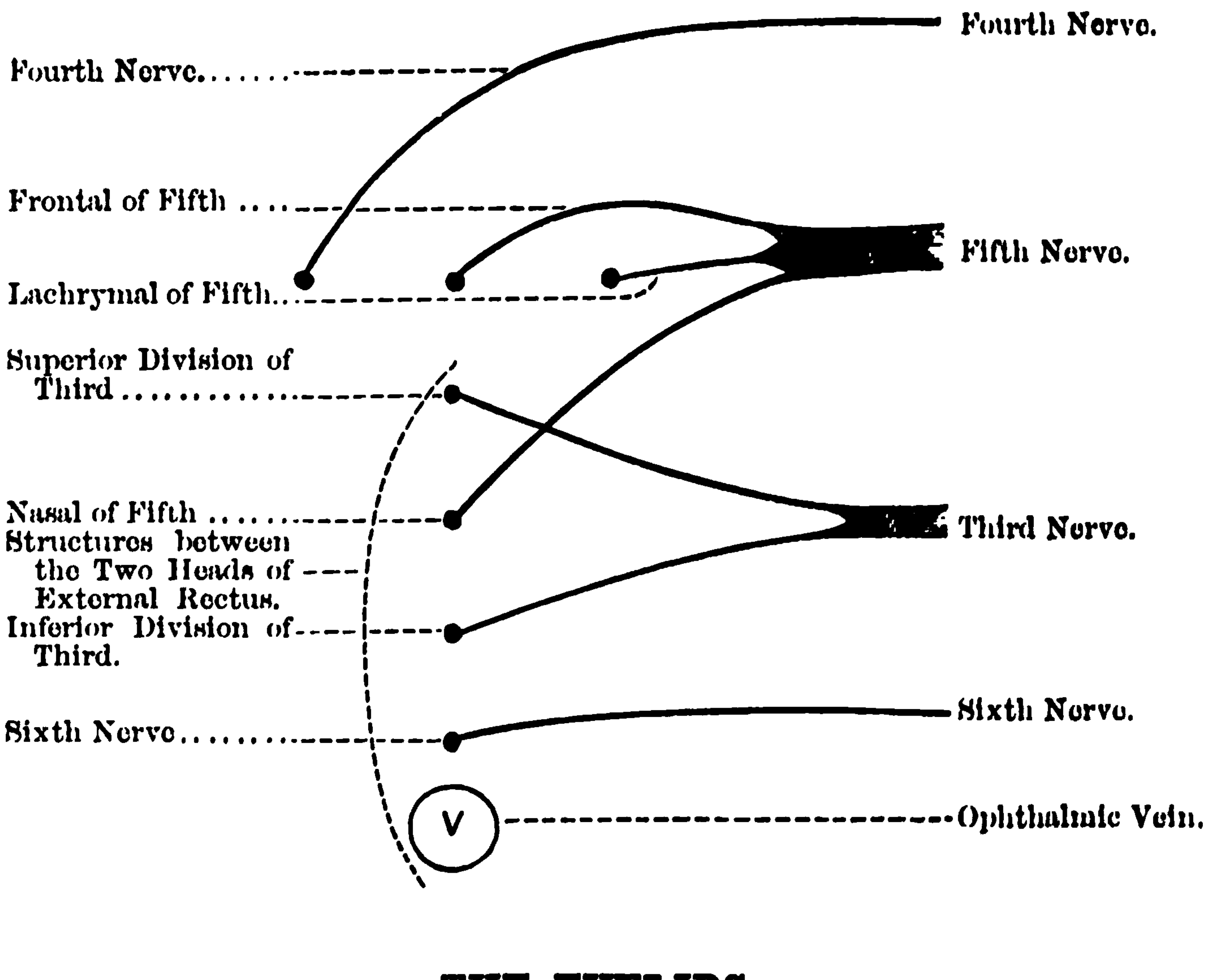
surrounded by the carotid plexus, and with the sixth nerve to its outer side. On the *outer* wall are the third, fourth, and first division of the fifth nerve, in that order from above downwards (Fig. 112). Through the centre of this sinus the blood flows in an irregular channel lined by endothelium. Pressure on the sinus will be indicated by venous engorgement of the eyeball and orbital cavity, and paralysis of some of the ocular nerves, especially the third and fourth. The pressure may be produced by anything that causes enlargement of the tip of the temporo-sphenoidal lobe of the cerebrum, as a gumma or an abscess; also by aneurism of the internal carotid in the sinus. In the **sphenoidal fissure** the position of parts is considerably altered—(1) The fourth nerve to the inner side; (2) the frontal branch of the fifth; and (3) the lachrymal branch of the fifth. These three nerves are above all

the muscles, and lie nearly on one level, just under the periosteum, the fourth being to the inner side. Then comes (4) the upper division of the third nerve; (5) the nasal branch of the fifth; (6) the lower division of the third nerve; (7) the sixth nerve; and lastly, and most internal of all, (8) the ophthalmic vein. The various nerves may be pressed upon by growths, involving this fissure, and also by syphilitic or rheumatic periostitis.

NOTE.—The structures named from 4 to 8 inclusive are all found between the two heads of the external rectus (Fig. 113).

Fig. 113.

RIGHT SPHENOIDAL FISSURE.



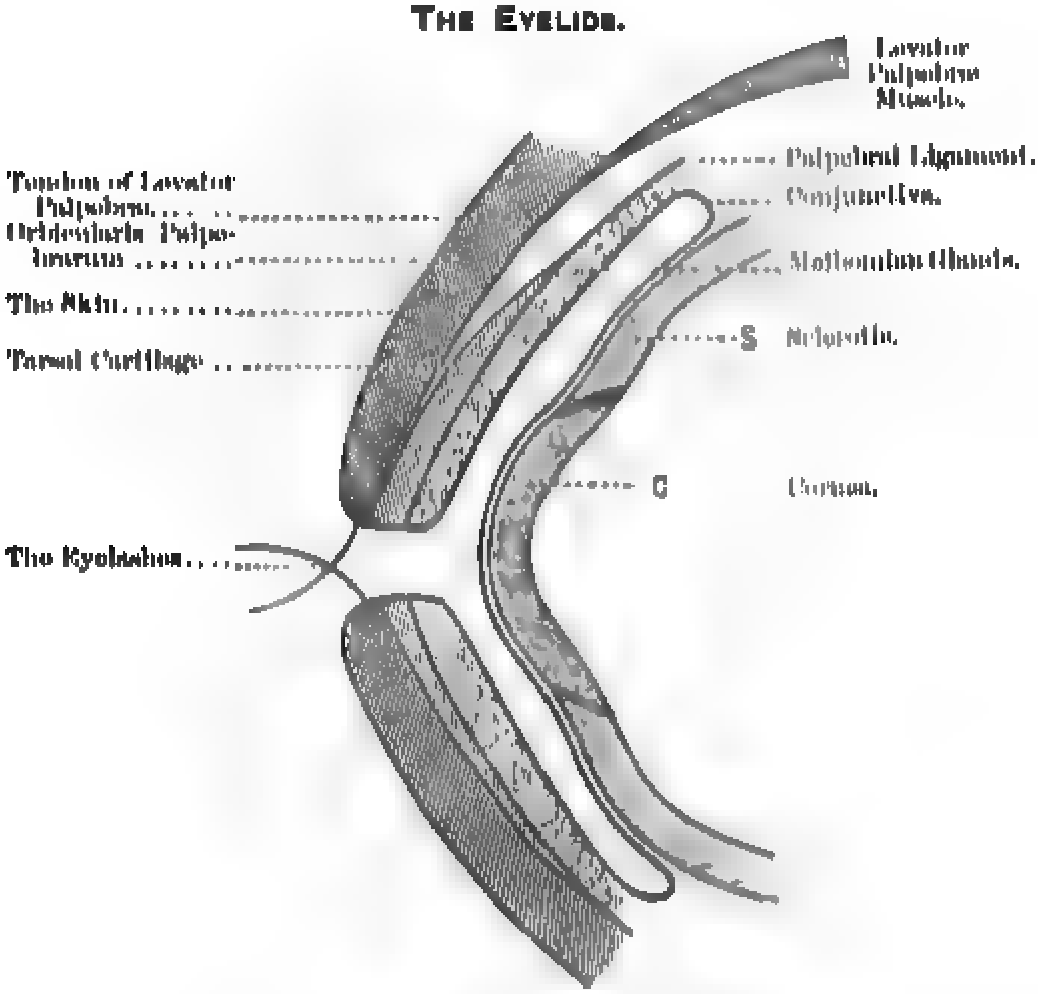
THE EYELIDS.

The eyelids are opened by the levator palpebræ, supplied by the *third* nerve, and shut by the contraction of the orbicularis oculi, supplied by the *facial* nerve. **Structure**—(1) The skin, (2) the orbicularis muscle, (3) loose connective tissue, (4) tendon of levator palpebræ (in the upper lid only), (5) the tarsal cartilage, into the *anterior and lower* part of which the levator palpebræ is inserted;

(6) palpebral ligament, (7) Meibomian glands, (8) conjunctiva, the mucous membrane of the eye, which lines the inner surface of the eyelids, and is reflected from them over the fore part of the sclerotic and cornea (Fig. 114). In the palpebral part of the conjunctiva there are many nodules of adenoid tissue, also mucous follicles and papillæ; in the condition known as **granular lids,** or **Trachoma,** these structures are much hypertrophied, and cause great irritation of the upper half of the ocular conjunctiva, leading directly to

Fig. 114.

THE EYELIDS.



pannus, and, after cicatrization, to inversion of the eyelashes and entropion. The common **tarsal cyst** is a retention cyst developed in one of the Meibomian glands, and should be removed *from the inside* by everting the lid, cutting through the conjunctiva, and shelling it out. A **dermoid cyst** is often met with at the upper and outer angle of the orbit, under the orbicularis muscle;

it is very thin walled, and contains epithelial cells and fine hairs. It is attached to the periosteum, and very often causes a depression in the bone as well, but the superficial structures move freely over it. The wall of the sac is usually very thin, and a very careful and tedious dissection is required to remove it; occasionally, it is connected with the dura mater. These cysts are developed in the situation of the inner end of the embryonic fronto-orbital fissure. Dermoids are also met with occasionally at the inner and lower angle of the orbit, in the situation of the upper end of the embryonic naso-maxillary fissure: the nasal duct represents a persistent portion of the same cleft or fissure. One must be very careful not to confound a meningocele, in this situation, with a dermoid cyst.

The Eyeball (Fig. 115).—The eyeball consists of three coats and the refracting media. The **outer coat** is formed by the sclerotic and cornea. (*a*) The *sclerotic* forms five-sixths of the circumference of the globe, and is composed of strong fibrous tissue, being thicker behind than in front: its weakest part is about a quarter-of-an-inch behind the cornea. (*b*) The *cornea* forms the anterior sixth of the circumference of the globe, forming a small projection in front, being the segment of a smaller sphere than the sclerotic. It consists of five layers—(1) Anterior epithelium—squamous and stratified, (2) anterior elastic lamina of Bowman, (3) the corneal tissue proper, (4) posterior elastic lamina of Descemet or Demours, and (5) the posterior epithelium—a single layer of squamous cells. The corneal tissue is continuous with the sclerotic, but the opaque sclerotic overlaps the cornea very much in the same way as a watch-glass is overlapped by the edge of the groove that receives it. It is important to remember this in making incisions about the corneo-sclerotic junction.

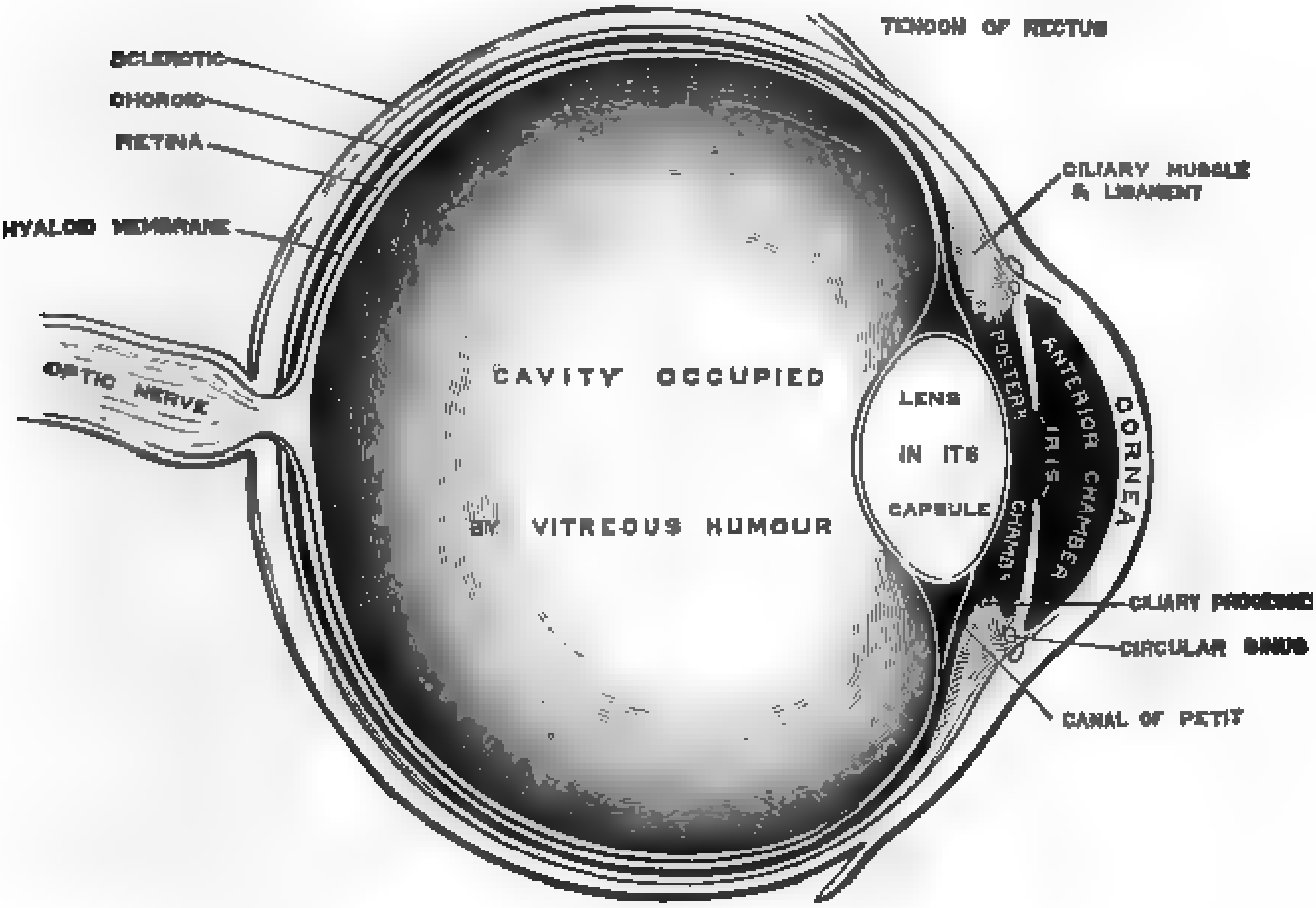
The **middle coat** consists of the choroid, ciliary body, and iris. (*a*) The **Choroid** is the vascular and pigmented coat of the eyeball, and is often the seat of melanotic sarcoma. It consists of—(1) The lamina supra-choroidea and the lamina fusca, which connect it with the sclerotic, and between which is found a lymph space. (2) The venæ vorticosæ, which end in the ophthalmic vein and return the blood from the globe; in cases of increased intra-ocular tension, as in glaucoma, pressure on these veins is indicated by the dilated

and enlarged veins observed on the *surface* of the sclerotic. (3) A closely-set capillary plexus, formed by the short ciliary vessels, known as the tunica Rusychiana. (4) The lamina vitrea, and (5) the layer of hexagonal pigment cells, which may be regarded as belonging either to this coat or, more properly, to the retina. The choroid is the nutritive tunic of the eyeball, having an especial

Fig. 115.

ANTERO-POSTERIOR SECTION OF EYEBALL.

(From GRAY'S "Anatomy.")



relation to the vitreous humour. Disease of the choroid may be primary, that is, beginning in the choroid *(choroiditis)*, or secondary to iritis, the mischief spreading backwards and involving the choroid *(irido-choroiditis)*. There are two clinical signs that point very strongly to choroidal disease, the first is diminished tension of the globe, and the second is the presence of floating opacities in the vitreous. (*b*) The **Ciliary body** consists of the ciliary processes and

the ciliary muscle—the muscle of accommodation; it arises from the posterior surface of the cornea and sclerotic junction close to the canal of SCHLEMM and the spaces of FONTANA, and is inserted into the choroid, opposite the ciliary processes. The vascular supply, like that of the choroid, is derived from the short ciliary arteries. (*c*) The *iris*—this is also a muscular structure, and forms a self-acting diaphragm, excluding or admitting light as required, like the diaphragm of a microscope, becoming narrower during active accommodation (equal to *high power* of microscope) and widening during passive accommodation *(low power).* It consists of the following structures:—(1) In front, a layer of epithelial cells, continuous with those on the posterior surface of the cornea. (2) A stroma, formed of cells and connective tissue bundles arranged in a radiating manner towards the pupil, and which gives the iris a striated, fibrous look; when the iris is inflamed this fibrous look is lost, and the iris seems smooth and dull in appearance. (3) Non-striped muscular fibres arranged in a circular and radiating manner; the circular fibres form the *sphincter pupillæ* and surround the margin of the pupil, the radiating form the *dilator pupillæ.* (4) The posterior surface is covered with pigment of a deep purple tint, known as the *uvea.* The vascular supply of the iris is derived, for the most part, from the two long ciliary arteries which form the greater and the lesser arterial circles of the iris; it also receives blood from the anterior ciliary arteries, which are derived from the muscular branches, and which join the great arterial circle. The iris is very vascular, almost resembling erectile tissue, and it often affords important information as to the state of the cerebral circulation; thus, when the brain is anæmic, as in typhoid fever, the pupil is dilated, but when the brain is engorged, as in typhus fever, the pupil is contracted. For the same reason it is also slightly contracted in iritis. The circular fibres are supplied by the third nerve, and the radiating by the sympathetic. In the fœtus the pupil is closed by a delicate vascular membrane, which thus divides the chamber of the aqueous into two separate compartments—the *membrana pupillaris;* it begins to disappear about the seventh month, and has usually quite disappeared, vessels and all, before birth. Occasionally traces of it remain after birth, and occasionally it is permanent, causing blindness. In some animals it remains

apparent for a few days after birth, such being said, in popular parlance, to be born blind, but to compensate for this few days' blindness, it is said they see in the dark ever afterwards. Its remains in the human eye are apt to be mistaken for old iritic adhesions; they form thin shreds of the *same colour* as the iris, and are attached to its *anterior* surface close to its pupillary border. They are longer and more slender than posterior synechiæ, and are not attached to the lens capsule. The entire membrane is the anterior portion of the *capsulo-pupillary membrane*, which at one time forms a complete fibro-vascular covering of the lens; the capsulo-pupillary membrane is developed from the enclosed mesoblast, and is supplied by a branch of the central artery of the retina, which passes forward in the axis of the globe in a canal in the vitreous humour (Canal of STILLING), and breaks up at the back of the lens into a brush of capillaries.

At its circumference the iris is connected to the cornea by the *ligamentum pectinatum iridis*, which is derived from the posterior elastic lamina of that tunic. Passing through this ligament are a number of cavernous spaces, known as the spaces of FONTANA; these communicate with the canal of SCHLEMM, a sinus tunnelling the choroid near its corneal junction. This sinus is either a vein or a lymph canal, having a very intimate relation with the veins of the globe, and in this way, therefore, the aqueous humour is brought into very direct relation with the venous system. The pupillary margin of the iris is free, and floats in the aqueous humour; in cases, therefore, of penetrating wounds of the cornea, the iris is apt to prolapse, being carried out with the gush of the aqueous fluid. This is an exceedingly troublesome and serious complication, and unless reduced, may give rise later to recurrent attacks of iritis, or even to sympathetic ophthalmia, from the irritation caused by the adhesion of the iris to the corneal cicatrix. Sometimes prolapse occurs in the case of wounds, made by the Surgeon, in the ciliary region for the purpose of removing an opaque lens *(cataract)*; to avoid this as far as possible, a small bit of the iris is removed opposite the wound, but, even with this, one must be careful to see that no part of the iris is included in the wound, as this will delay healing very much. The iris is a muscular structure, and, therefore, may be made to contract or dilate

like other muscles; this fact is made use of in corneal wounds to prevent prolapse: for example, in wounds situated near the circumference of the cornea, whether the result of accident or made by the Surgeon, a solution of Calabar bean *(eserine)* is dropped into the eye, since this causes *contraction* of the iris, and will, therefore, draw it away from the wound; whereas in wounds near the centre of the cornea, a solution of atropine is used to *dilate* the pupil, and thus again carry the iris away from the wound.

The **inner coat** consists of the *retina*, which is formed by the expansion of the optic nerve, and is the *seeing* part of the eye. It is thickest behind, and becomes gradually thinner as it passes forwards; it ends by a jagged margin, the *ora serrata*, just behind the ciliary body. From within outwards it consists of the following layers:—(1) Internal limiting membrane, next the vitreous humour; (2) layer of nerve fibres; (3) layer of nerve cells; (4) inner molecular layer; (5) inner nuclear layer; (6) outer molecular layer; (7) outer nuclear layer; (8) external limiting membrane; (9) layer of rods and cones; and (10) layer of hexagonal pigment cells. At the **yellow spot,** however, the structure is a little different—the layer of nerve fibres is absent, but the layer of nerve cells consists of several strata; the rods are few, and absent altogether in its centre, but the cones are many and large. All the other layers are thinner, and there are scarcely any blood-vessels, only a few capillaries. When looked at, by the aid of the opthalmoscope, the following parts may be recognised:—(1) The *optic disc* or *blind spot*, one-tenth of an inch to the inner side of the axis of the eye; (2) the *macula lutea* or *yellow spot*, as nearly as possible in the axis of the eyeball: in its centre is a slight depression—the fovea centralis; (3) the *arteria centralis retinæ*, which enters through the optic disc and divides into four or five branches, which pass over the retina in various directions, but seem to avoid the macula lutea; and (4) sometimes the vessels of the choroid may be seen.

The fundus itself is bright ferrety red, the depth of the colour depending on the complexion of the individual; this red appearance does not come from the retina—which is invisible except under rare conditions—but from the choroid. When the lens is opaque, as in cataract, this redness is obscured more or less, and *when it cannot* be seen at all the cataract is said to be "ripe."

The optic disc is of a lighter pink than the rest of the fundus, and is circular or slightly oval, and very markedly so, should the patient be astigmatic; the centre of the disc is still paler, and into this the greater number of the blood-vessels dip. This central white spot represents a hollow cup—the *physiological cup*—left by the optic nerve fibres as they radiate from the centre of the disc towards the periphery. Compare this with the large, deep *pathological cup* seen in glaucoma; in health the cup does not extend to the edge of the disc, whereas in glaucoma it does, and is also very deep. In atrophy of the optic nerve, the cup though wide is very shallow. In health the edge of the optic disc is sharply defined, and it is often surrounded by a white ring—the scleral ring—which corresponds to the edge of the sclerotic. In cases of myopia a greyish white crescentic patch is often seen on the apparent inner side of the optic disc, in indirect examination (*i.e.*, next the yellow spot). This is known as the "*myopic crescent*," and is due to atrophy of the choroid; it is also known as a "*posterior staphyloma.*" In some cases the lamina cribrosa may be distinguished like a number of dots at the bottom of the physiological cup. The veins of the retina are easily distinguished from the arteries by their larger size, deeper colour, and single outline; the arteries have a double outline and pursue a straighter course. The visible retinal vessels are few in number, widely spread, and are what are known as terminal vessels, as the arteries do not anastomose with each other, while the choroidal vessels, if seen, branch and anastomose freely, forming a closely set network; in embolism, therefore, of the retinal vessels, an *infarct* is produced. In cases of glaucoma and aortic regurgitation one may sometimes be able to see the vessels pulsating.

As the optic disc lies to the *nasal side* of the posterior pole of the eye, in the indirect method of ophthalmoscopic examination, the cornea must be turned a little *inwards*, towards the patient's nose, to bring the disc opposite the pupil; in this movement, of course, the back of the eye is carried *outwards*, and the patient must be directed to turn his eye, not his head.

Advantage is taken of the red reflection of the fundus, but especially of the pale disc, in examining for **floating opacities** in the vitreous. The Surgeon sits about twelve to eighteen inches in

front of the patient's eye, and directs him to move his eye sharply and freely from side to side, and up and down, and then quickly to fix it so that the disc will be opposite the pupil, when the floating particles will be seen passing across the optic disc, like figures in a magic lantern, as they continue to move through the vitreous from their inertia, after the eye has come to rest. In this way, too, they are distinguished from opacities in the cornea and lens, or pigment spots on the fundus, which come at once to rest when the eye stops.

Anatomically, the **Refracting Media** of the eye are—(1) **The Cornea.** (2) **The Aqueous Humour,** which fills the space between the cornea in front, and the lens with its suspensory ligament behind; this space is partially subdivided into two by the iris—the *anterior* and *posterior chambers* of anatomists. It should be noted, however, that oculists call the whole cavity the *anterior chamber*—their posterior chamber being the cavity containing the vitreous humour. In infants, the anterior chamber is very shallow, the lens being close behind the cornea; this probably explains the occurrence of *anterior polar* or *pyramidal cataract,* which is caused by a localised inflammation of the lens capsule and the layers immediately below it, and is usually the result of ophthalmia neonatorum, which has probably caused a central perforating ulcer of the cornea. (3) **The Lens** with its **Capsule,** which are held in position by the suspensory ligament. (4) **The Vitreous Humour** with its **Hyaloid Membrane.**

Physiologically, however, refraction only takes place at three surfaces—the anterior surface of the cornea, the anterior surface of the lens, and the posterior surface of the lens.

The eyeball lies in the orbital cavity, and is surrounded by much finely granular fat, which forms a soft elastic packing for it. Coursing through this fat are many arteries and veins, going to and returning from the globe, and it occasionally happens that we find here some one of the many forms of aneurism.

The conditions giving rise to "**orbital aneurism**" are very numerous and of a most varied character, and extremely difficult to diagnose with certainty; and sometimes, even at the *post-mortem,* nothing abnormal is found to account for the symptoms *during life.*

Symptoms.—Pulsation, displacement of the eyeball, and sometimes loss of sight, from pressure optic neuritis; in the arterio-venous forms we have the usual thrill and bruits. **Conditions present in some cases**—Cirsoid aneurism, aneurism by anastomoses, arterio-venous aneurism of the orbit, pulsatile dilatation of the vessels of the orbit—as in exophthalmic göitre, communication between the internal carotid artery and the cavernous sinus, aneurism of the internal carotid, tumours pressing upon the termination of the ophthalmic vein, thrombosis of the cavernous sinus, dilatation of the carotid artery, aneurism of the ophthalmic in the cranium, and occasionally true aneurism. As regards the **diagnosis**—note (1) that ordinary aneurism and varicose aneurism tend to grow larger, so also would pulsating malignant tumours; and (2) that aneurismal varix does not tend to increase in size.

The arterio-venous varieties are caused by wounds implicating simultaneously an artery and vein; the author has seen two such cases, one caused by a knitting-needle, the other by an umbrella wire. This fat in the orbit is often the seat of **abscess**, due either to a primary septic cellulitis, or from disease of the neighbouring bones, especially strumous caries of the lachrymal or ethmoid; in this condition there may be no redness of the skin as the abscess is so deep, but there is usually œdema of the lid. At the inner angle of the orbit the facial and ophthalmic veins communicate, and in cases of malignant facial carbuncle, the septic thrombosis readily extends along the facial vein and through the ophthalmic to the cavernous and other sinuses, speedily setting up a condition of septic embolism and pyæmia. In young people also, soft rapidly growing sarcomatous tumours may start in the cellular tissue round about and behind the globe, from an injury, as a blow with a snowball. Ivory exostosis, and enostosis growing in the frontal sinus, are also sometimes found in the inner wall of the orbit, displacing the eyeball. Tumours of purely *local* origin, pressing upon the optic nerve and displacing the eyeball, will cause uni-lateral optic neuritis ("*choked disc*"), followed by atrophy of the nerve pressed upon; in tumours of *cerebral* origin, the same appearances are usually found in *both* eyes. Between the packing of the cavity and the globe itself, however, we find a membranous sac, which is known as the *capsule of Tenon* or the *tunica vaginalis*

oculi. It is regarded as a distinct serous sac, with a parietal layer covering the fatty tissue, and a visceral layer enclosing about three-fourths of the entire globe, extending from the base of the orbit to the optic nerve, with the sheath of which it blends. Just as in the case of the peritoneum, lymphatic vessels begin on the epithelial-lined surface by stomata. The ocular muscles pierce this capsule as they pass to their insertion into the choroid; in operations therefore for strabismus, this capsule must be opened before the tendon is thoroughly exposed; and since a serous cavity is thus opened, the necessity for strict antiseptic precautions is very evident.

THE LACHRYMAL APPARATUS.

This consists of—(1) The lachrymal gland and its ducts opening around the outer canthus, especially on the upper lid; (2) puncta lachrymalia, which are the openings into (3) the canaliculi, which lead into (4) the lachrymal sac, from which (5) the nasal duct descends to open into the inferior meatus of the nose (Fig. 116).

Puncta Lachrymalia and Canaliculi.—The puncta are two small apertures, situated one on the free margin of each lid, about one quarter of an inch from the inner canthus; they are the openings of two small ducts—the canaliculi. Each canaliculus takes a curved course inwards—the upper first passing upwards and then curving downwards; the lower first passing downwards and inwards, and then curving upwards and inwards; and therefore, in introducing a probe, or in slitting open the canaliculus, the lid should be drawn outwards, to make it as straight as possible. The lower canaliculus is shorter, wider, and not so much arched as the upper, and is the one usually opened, both because it is easier, and also because it carries off most of the fluid. In doing this the edge of the knife is directed inwards, and passed first a little downwards and a little inwards, and then inwards and very slightly upwards, till it touches the lachrymal bone.

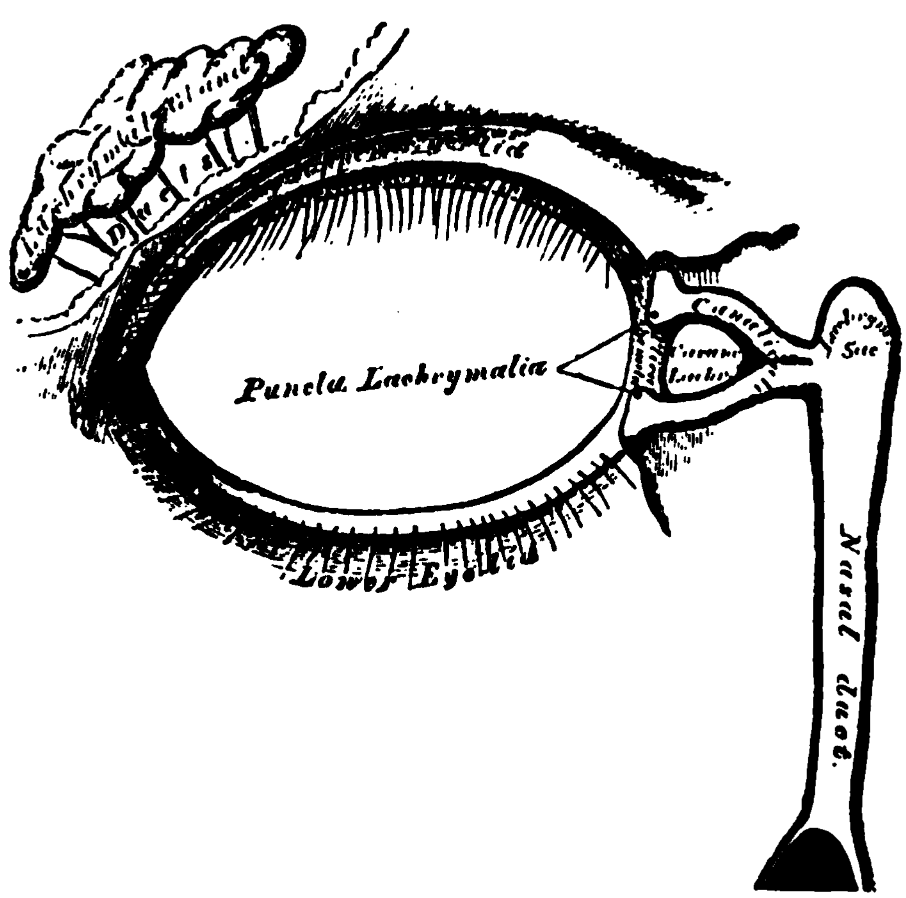
Lachrymal Sac.—If from any cause this sac requires to be opened (*e.g.*, when suppuration has occurred in it), it should be opened from the *outer* side, because the angular artery (the termination of the facial) and the large angular vein are on its inner or nasal side. The sac is placed in the inner angle of the orbit, and crossed in front by the tendo-oculi and some of the

inner fibres of the orbicularis muscle, a little above its middle: while on its orbital surface is the tensor tarsi muscle. If the finger be placed on the inner edge of the orbit, this little tendon will be felt to tighten every time the eye is closed, and still more so if the eyelid be drawn outwards. In this way the tendon serves a most important purpose in helping to drain away the tears, as its pressure empties the lachrymal sac, and then, when it relaxes, the sac sucks up the tears through the canaliculi—resembling, in fact, an ordinary injection syringe. In opening an abscess of the lachrymal sac, the knife must be entered just below this tendon, and towards the outer side, to avoid the angular vessels.

Fig. 116.

THE LACHRYMAL APPARATUS.

(From GRAY'S "Anatomy.")



Nasal Duct.—This duct leads from the lachrymal sac to the inferior meatus of the nose. The edges of the canal through which it passes may be felt on one's own person, by pressing the finger on the inner edge of the orbit on its lower aspect. To pass a probe through it, it should be directed downwards, outwards, and a little backwards (the direction of the duct). Obstruction of this duct leads to distension, and consequently to irritation

and disease of the lachrymal sac, and, unless properly treated, inflammation and suppuration follow, which may end in fistula lachrymalis. It is also a cause of "Epiphora" or "Stillicidium Lachrymarum," trickling of tears over the cheek, or "Watery Eye." Each duct opens into the anterior part of the inferior meatus of the nose, immediately below, and about a quarter of an inch behind, the anterior end of the inferior turbinated bone, or an inch behind the orifice of the nostril, and about three-quarters of an inch above the floor of the nose; they are about half-an-inch long, and they are narrowest about the middle.

"**Watery Eye.**"—This condition may be due to excessive secretion of fluid, when it is known as "*Epiphora;*" or to some obstruction preventing the proper drainage of a normal quantity of fluid, and it is then called "*Stillicidium Lachrymarum.*"

Causes of Watery Eye.—(1) Obstruction of the nasal duct from chronic thickening of the mucous and submucous tissue, tumours and polypi of the nasal cavities and antrum; (2) from increased secretion; (3) from obstruction of puncta or canaliculi, due to chronic inflammation or warty growths; (4) in cases where the puncta are displaced, as in facial paralysis; (5) suppuration of the sac from acute inflammation, probably following chronic thickening of its lining membrane, with increased secretion of mucus, forming a little tumour (*mucocele* or *chronic dacryo-cystitis*), which is very apt to inflame and suppurate; (6) chronic conjunctivitis of the lower lid, causing increased thickness and eversion of the lid, leading to displacement of the punctum; and (7) congenital narrowness of the puncta.

In chronic cases the usual treatment is to open the inferior canaliculus. It is true, probes might be passed, and the opening gradually dilated, just as in ordinary stricture of the urethra; but this plan is exceedingly slow, painful, unnecessary, and not satisfactory even when performed. The quickest and best way is to open the canaliculus, thus transforming it from a round pipe into an open gutter. After twenty-four hours rest probes are passed down from the lachrymal sac into the nasal duct. Each probe must be kept in for ten or fifteen minutes (one probe at each sitting will usually be sufficient) and a larger size passed *every* second or third day. Before passing the probe, Dr Argyll

ROBERTSON curves it slightly, so that it may enter the duct more easily; he judges of the proper amount by placing the curved part against the side of the patient's nose and eyebrow just over the sac and duct, and when it lies level with the skin it is sufficiently curved. It is then passed along the opened canaliculus till the point comes into contact with the lachrymal bone, when the handle is raised till it lies over the supra-orbital notch, and the probe is then to be pushed in the direction above indicated—downwards, backwards, and a little outwards.

SURFACE VESSELS OF THE EYEBALL.

By this is meant vessels that can be seen, more or less distinctly, with the naked eye in certain diseased conditions.

1. **The Vessels Proper to the Conjunctiva.**—These vessels are usually known as the posterior conjunctival branches, and are derived from the palpebral and lachrymal arteries. In health they are too small to be well seen, but in simple *conjunctivitis* they can be seen to perfection. They are of a bright brick-red colour, superficial, moving with the conjunctiva when it is slid over the globe, can be emptied for a time by gentle pressure, are tortuous, forming open loops, largest at the circumference of the globe, and growing smaller and less marked as they approach the edge of the cornea.

2. **The Vessels of the Iris.**—These are chiefly derived from—(*a*) The two **Long Ciliary** arteries which pierce the posterior part of the sclerotic, and run forwards along each side of the eyeball, between the sclerotic and the choroid to the ciliary ligament, where they each divide into two branches and form the great arterial circle of the iris, from which smaller branches pass to form the lesser circle at the pupillary margin. (*b*) The **Anterior Ciliary** arteries, which are derived from the muscular branches, and lie in the *sub-conjunctival* tissue, and divide into two sets of branches—(1) The *perforating* branches, which pierce the sclerotic about a line from the edge of the cornea, supply the sclerotic and ciliary body, and end in the great arterial circle of the iris; and (2) the *epi-scleral* non-perforating branches, which are too small to be seen in health, but in **Iritis**, and in some deep-seated inflammatory affections of the cornea, they form a zone ("circumcorneal zone") about an

eighth-of-an-inch wide surrounding the cornea, *pink* in colour, and consisting of closely packed, straight, and very fine radiating vessels. This injection is sub-conjunctival, and the vessels do not therefore move when the conjunctiva is slid over the globe, nor can they be emptied or affected in any way by pressure. Marked as these differences are between the injection of iritis and that of conjunctivitis, yet iritis itself must not be diagnosed on these grounds alone, as other conditions produce the same injection. Besides the congestion in iritis, there is the altered colour of the iris, and sluggish action of the pupil to light; there is slight narrowing and irregularity of the pupil, and the iris loses its fibrous look and becomes smooth, dull, and muddy. There is deep-seated pain shooting up the side of the head, nose, and eyebrow, which is usually worst in the early morning; the pain is conveyed along the supra-orbital, the supra-trochlear, the infra-trochlear, and the nasal branches of the ophthalmic division of the fifth. There is further impairment of vision, and often great watering of the eye, and photophobia from irritation of the lachrymal nerve. In **Conjunctivitis** the pain is smarting and superficial (like sand in the eye), the secretion is rather sticky than watery, and gums the lids together during the night, and the vision is not impaired except for the moisture in front of the eye. It is very important to distinguish between conjunctivitis and iritis, as the treatment is so different, and the result of a mistaken diagnosis might be serious for the patient.

3. The **Veins corresponding** to the anterior ciliary arteries *(the epi-scleral venous plexus)* are sometimes found to be engorged, forming a scanty reticulated zone of dusky colour, with sometimes the larger trunks standing out in a sharply defined manner on the surface of the sclerotic. When this is the case it usually points to the serious condition known as glaucoma—a condition characterised by increased intra-ocular tension, the increased pressure obstructing the venous return through the vorticose veins of the choroid.

4. In **Sclerotitis** *(rheumatic ophthalmia)* there is usually some conjunctival and subconjunctival injection, but the characteristic feature is the peculiar bluish or violet tint of the sclerotic itself, due to the injection of numerous minute vessels in its substance. This dusky pink injection is most marked at the edge of the cornea and shades off as we pass backwards, but there is no visible

anastomoses. There is also some thickening of the sclerotic from inflammatory effusion. This condition is found in middle-aged patients of a rheumatic constitution and is usually limited to a small area close to the edge of the cornea; in young adults it is usually gonorrhœal in nature, and resembles, as regards its pathology, a similar condition attacking certain large joints, and other fibrous tissues, such as the tunica albuginea of the testicle. It is apt to involve the ciliary processes and iris; when this takes place there will be deep-seated pain and injection, and great sensitiveness of the eye to touch in the ciliary region, together with slight irregularity of the pupil. When the condition passes off it leaves the sclerotic thinned and of a bluish tint from deep-seated pigmentation, and may even be a cause of anterior staphyloma.

The **Cornea** itself is non-vascular, but in interstitial keratitis, where the cornea becomes like ground glass, a condition so frequently associated with congenital syphilis, blood-vessels from the periphery often penetrate into *its substance* at some little distance from the surface. This gives rise to a patch of peculiar colour—the "salmon patch" of HUTCHINSON; with a lens, the "patch" can be seen to consist of a fine, straight, and closely packed plexus of vessels.

To confirm this, look for the **signs of congenital syphilis,** such as—(1) The notched, pegged, and widely separated upper central incisors; (2) sunk bridge of the nose; (3) hazy cornea from old interstitial keratitis; (4) radiating scars at the angles of the mouth; (5) prominent forehead; (6) the patient probably the eldest of the family; and (7) the presence of *choroiditis disseminata.* Myopia is a not uncommon result of interstitial keratitis; this is caused by the projection forwards of the cornea, due to thinning of its layers as a result of the inflammation, but is also partly the result of increased intra-ocular tension.

Further, in the condition known as "**pannus,**" there is a new growth of very vascular tissue just beneath the corneal epithelium, over part of the surface (usually the upper part) of the cornea. The usual cause of pannus is granular lids *(granular conjunctivitis or trachoma)* where the conjunctiva of the lids is studded with minute elevations which constantly irritate the cornea. This condition of the lids is caused by exposure to heat and glare, and is much more common in Palestine than in this country.

MOVEMENTS OF THE EYEBALL.

There are, in all, seven **muscles** acting on the globe—the four recti, the superior and inferior obliques, and the levator palpebræ superioris. Their nervous supply is as follows—The external rectus is supplied by the *sixth* nerve; the superior oblique by the *fourth*; and all the rest by the *third* or *motor oculi*—viz., levator palpebræ superioris, superior rectus, internal rectus, inferior rectus, and the inferior oblique.

Movements.—(1) To **raise** the eyeball, the superior rectus and inferior oblique act together; the superior rectus pulls upwards and inwards, the inferior oblique pulls upwards and outwards, but acting together the eye is raised directly upwards. (2) To **depress** the eyeball the inferior rectus and superior oblique act together; the inferior rectus displaces the ball downwards and inwards, the superior oblique downwards and outwards, but acting together the ball is displaced directly downwards. (3) The external rectus **abducts** the eyeball, while (4) the internal rectus **adducts it.**

"Fire" in the Eye.—This is a condition of irritative conjunctivitis, due usually to a foreign body sticking in the eye, or else a recent abrasion produced by a foreign body, as bits of metal, spots of freshly slaked lime, etc. The usual history is, that it is in a working man in good health; the onset is sudden, and only one eye is affected. First, gently separate the lids and examine the exposed part of the globe with the unaided eye, and afterwards, if necessary, with an ordinary pocket lens; then make the patient face a window and ask him to follow with his eye the movements of your finger, while you watch the reflection of the window on his cornea. Should there be an abrasion or foreign body sticking in the cornea, the image of the window will be broken and irregular at the abraded part. Small foreign bodies embedded in the cornea become surrounded by a hazy zone, and are then easily detected; they are apt to adhere to the inner surface of the lids, especially the upper, and the next thing therefore to be done is to examine the inner surface of the lids. By gently depressing the lower lid its inner surface will be exposed; but for the upper, the lid must be completely everted over a probe or the handle of a pen. Lay the probe on the upper

lid, direct the patient to look down, and then gently take hold of the ciliary margin of the lid; press the probe downwards and draw the lid forwards and then upwards, when the cartilage will tilt over. In doubtful cases we must use oblique illumination by the aid of a lamp in a dark room, and a lens of about three inches focal length, such as is used with the ophthalmoscope, by this means we concentrate the light on the cornea, and any abrasion or opacity will be readily seen. This may also be supplemented by examining the illuminated cornea by the aid of a pocket lens. An abrasion may be the starting point of spreading septic ulcer of the cornea and of pus in the anterior chamber (*hypopyon keratitis*). The treatment is to destroy the septic condition by antiseptic applications or the thermo-cautery, when the pus readily disappears from the anterior chamber, and the ulcer stops spreading.

Treatment. In many cases the foreign body can be easily removed, but when it is embedded in the cornea, drop a solution of cocaine into the eye, and then use a small spud, and passing it behind the foreign body, jerk it out; and afterwards, if there be much irritation, use a solution of cocaine or atropia. In the case of quicklime, wash the eye with a weak solution of vinegar (a teaspoonful to a cupful of water) and afterwards, to lessen the friction, use a drop of castor oil every half hour, or else a solution of atropia or cocaine. In penetrating wounds of the cornea, the aqueous humour escapes with a gush, and carries the iris with it (prolapse); the iris sticks between the lips of the wound and delays healing, and also, because the iris is a very sensitive structure, gives rise to great pain and irritation. The first thing to be done is to reduce the prolapsed iris if possible; for this purpose close the eye and rub the lid gently against the globe, and afterwards use a strong solution of atropia or eserine, according to the position of the wound. If it is not yet reduced, then the prolapsed part must be snipped off. Penetrating wounds of the "**dangerous zone**" of the eye (*ciliary region*) are specially dangerous, not only to the wounded eye, but to the other eye as well; in the wounded eye it is apt to give rise to iritis, cyclitis, and irido-choroiditis, and in the other eye, sympathetic ophthalmitis in three to six weeks after the injury, especially if the injured eye contains a foreign body, or if the iris be attached

to the cicatrix. The secondary inflammation usually takes the form of an irido-cyclitis or irido-choroiditis; the injection is but slight, but there is great sensibility of the eye to touch over the ciliary region. The exact cause is doubtful; it may be purely reflex, or spread through the optic nerve by continuity of tissue, or have a microbic origin; one thing is certain, that it most often follows wounds of the ciliary region, and that its first effects are observed in the same region of the other eye. A somewhat similar phenomenon is, I believe, observed in the case of dental caries; a tooth on one side is carious, and if it is not removed, stopped, or else kept well dressed with some antiseptic substance, the corresponding tooth on the other side will very often quickly become carious too. The change may possibly be trophic in its nature.

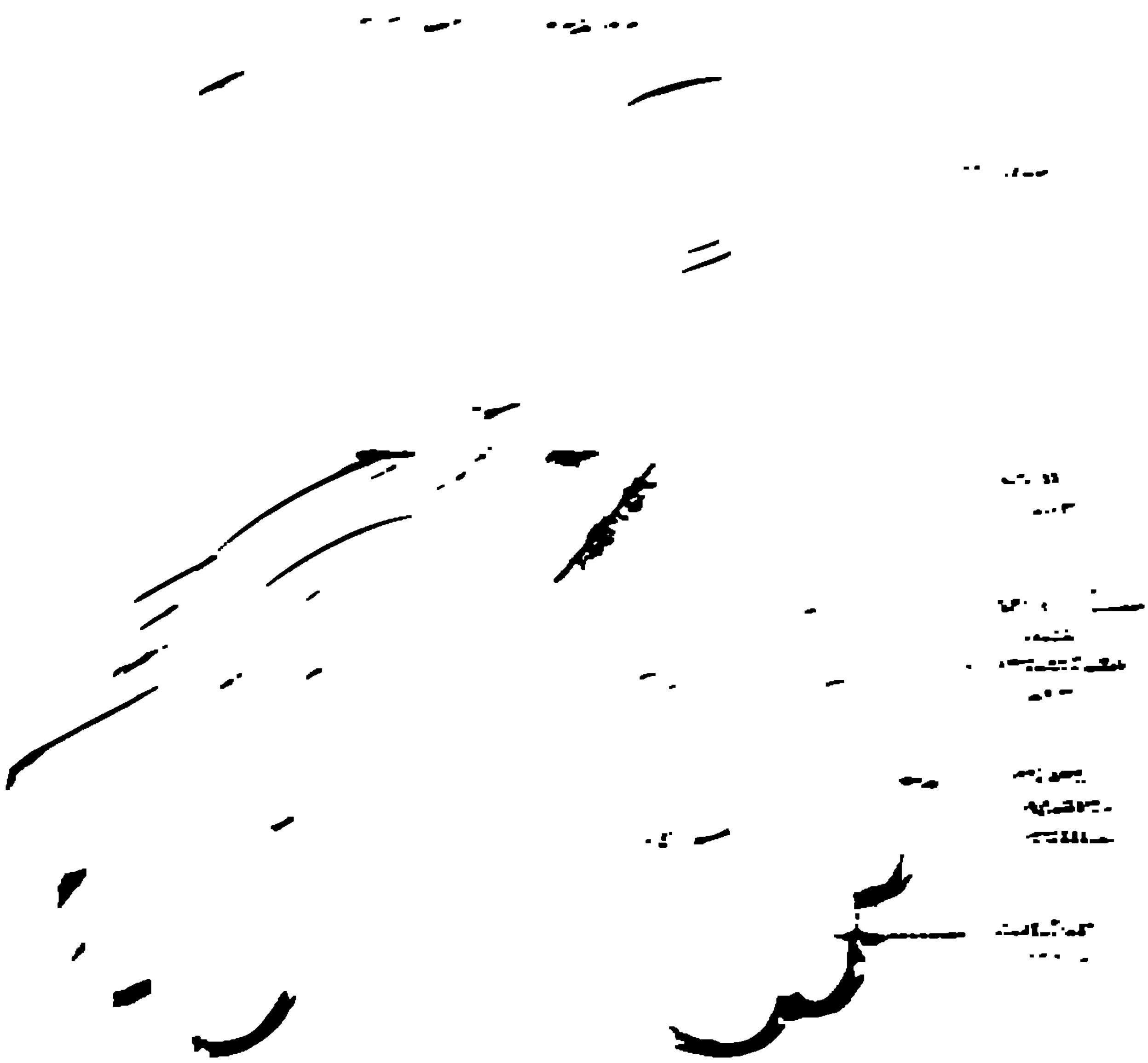
NERVES OF THE EYEBALL.

1. **The Optic Nerve.**—The deep origin of this nerve is from the posterior part of the optic thalamus *(pulvinar)*, the anterior pair of corpora quadrigemina, the corpora geniculata, and, according to some authors, from the angular gyrus, where, according to FERRIER, the visual centre is situated; but MUNK, on the other hand, places the centre on the outer convex surface of the occipital lobe. From the deep origin each tract winds obliquely across the under surface of the corresponding crus, and afterwards join each other to form the optic commissure. The optic nerves take origin from the commissure, pass through the optic foramina, pierce the sclerotic and choroid a little to the nasal side of the centre, and expand into the retinæ.

The white sheath of SCHWANN should cease at the lamina cribrosa, but in rare cases it does not do so, but is continued through the disc into the retina forming "**opaque nerve fibres**" as seen by the opthalmoscope; it usually affects tongue-like processes round the circumference of the disc. The processes are pure white, striated, and the free edge is feathered, or like carded wool. The rest of the fundus is normal, the vision is not at all affected, and the vessels crossing the white patch are not tortuous, as in patches of choroidal atrophy.

The exact course and origin of the fibres passing to each retina is still a disputed point. It is generally admitted that there is a partial decussation at the optic commissure, each *tract* supplying the corresponding half of each eye, *e.g.*, the left tract supplying the left half of each eye. Should, therefore, this tract be destroyed by disease, there will be blindness of the left half of both retinæ (which will thus correspond to the right half of each visual *field*). This is known as *Homonymous hemianopsia.* On the other hand, a lesion situated in the anterior part of the optic commissure will produce blindness of the inner half of each eye (the right half of one eye but the left half of the other). This is called *internal Heteronymous hemianopsia.* In the very rare and doubtful condition of *external Heteronymous hemianopsia* (blindness of the external half of each retina) there must be a double lesion situated at the outer margins of the sides of the optic commissure. But *hemianopsia* may also be caused by other conditions, such as detachment of the retina, and in **Coloboma iridis**—a congenital cleft or deficiency in the iris, due to the imperfect closure of the choroidal cleft of the fœtus, usually affecting the choroid as well, always found at the lower and inner aspect, and therefore the upper and outer part of the visual field is deficient. It is very often symmetrical; the white patch is bounded by a dense line of pigment, and over its surface the choroidal and retinal vessels may be seen. Occasionally small dermoid cysts of the iris are due to the unobliterated remains of this cleft; such cysts look like small white currants, semi-transparent, protruding into the anterior chamber, and partly occluding the pupil. Similar cysts may also arise as a result of a perforating wound of the cornea, whereby small pieces of DESCEMET's membrane, epidermal scales, or eyelashes are transplanted on to the iris, and form the germs of cysts—"implantation dermoids" (HULKE). Detachment of the retina is due to serous exudation between it and the choroid; it may begin at any part, but always gravitates by-and-by to the lowest part of the fundus.

It is doubtful what would be the result of a lesion situated in the visual centre. CHARCOT believes that the fibres that do not decussate at the optic commissure have already decussated in the corpora quadrigemina, so that the right centre would in this way



neuritis (*"choked disc"*), and finally atrophy of the optic nerve and gradual loss of sight, more or less complete; they may also be pressed on directly by tumours, either at the tract, chiasma, or optic nerve proper. They are also affected in injuries and diseases involving the optic foramina: in fractures through the anterior fossa of the skull, either from a fissure involving the optic foramen of that side, or from hæmorrhage into the sheath of the nerve; from tumours beginning in the orbital cavity, as sarcoma and exostoses; or from tumours invading the orbit from other parts, as sarcoma of the antrum or of the ethmoid cells, and large enostoses of the frontal sinus.

2. **The Third Nerve** (*Motor Oculi*). The deep origin of this nerve is from a grey nucleus in the floor of the aquæductus Sylvii, and which is the continuation of the grey matter of the anterior horn of the spinal cord. It is also connected with the locus niger and the corpora quadrigemina. At its superficial origin, on the inner side of the crus, close to the pons, it lies between the superior cerebellar and the posterior cerebral arteries. It then lies in the outer wall of the cavernous sinus, where it receives communications from the fifth and sympathetic, after which it enters the orbit, through the sphenoidal fissure. The *extrinsic* muscles supplied by this nerve have been already named. It also supplies two muscles *within* the eye—the *sphincter pupillæ*, and the *ciliary muscle*, by which the eye is accommodated for near objects. In looking at a near object *three* distinct events take place—(1) Contraction of the ciliary muscle; (2) contraction of the pupil; and (3) convergence of the eyeballs (by the internal recti)—all accomplished by the third nerve. In health a definite relationship exists between these three movements, which, if disturbed, will lead to defective sight. The centre for the reflex contraction of the pupil is in the corpora quadrigemina or medulla oblongata. The third nerve may be **paralysed** by cold, rheumatic inflammation or periostitis, syphilitic periostitis, gummata about the inter-peduncular space and pons, disease of the posterior cerebral artery or of the internal carotid in the cavernous sinus, and abscesses or new growths in the tip of the temporo-sphenoidal lobe, pressing on the outer wall of the cavernous sinus. It is very frequently, also, a result of central nervous disease.

Results of Paralysis.—(1) Ptosis, drooping of the upper eyelid, because the levator is paralysed; (2) external squint, as there is nothing to oppose the external rectus, which is supplied by the sixth nerve, and which is, therefore, not affected; (3) double vision, as the images are not thrown on corresponding parts of the two retinæ; (4) dilatation of the pupil, as the sphincter is paralysed, and, further, it is insensible to light; (5) loss of accommodative power for near objects, as the sphincter pupillæ, ciliary muscle, and internal recti are paralysed; (6) immobility of the eye in all directions; (7) giddiness will probably also be present, as the patient has a false idea of the relations of external objects to himself; (8) the globe is slightly more prominent, due to the action of the superior oblique (fourth nerve), which is not paralysed. Paralysis of the third often only affects a part of the nerve—*e.g.*, ptosis, and a fixed dilated pupil are frequently met with, without other signs. The squint in this case is *paralytic*, and the movements of the squinting eye are extremely limited (in contra-distinction to *concomitant* squint, where the squinting eye retains its full range of motion). It is also *divergent*, and the double images are therefore crossed—*i.e.*, the image belonging to the right eye appears to be to the left of the other (*Heteronymous squint*); in other words, the right hand image belongs to the left eye, and *vice versâ*. This is ascertained, in a darkened room, by means of a candle held about eight or ten feet from the patient, and a strongly-coloured red glass placed in front of each eye successively, by means of which one can tell which of the two images belongs to each eye. As the paralysed eye cannot move upwards or downwards, as the candle is moved the height of the images will vary according as the candle is above or below the horizontal plane, and the position of the images will be understood by remembering that the lower part of the visual field corresponds to the upper part of the retina, and *vice versâ*. The image formed by the squinting eye is fainter than that formed by the "**working**" **eye**, and is called the *false* image; patients by-and-by learn to disregard this image, and thus get rid of the inconvenience arising from the double vision. To find out the working eye, let the patient look steadily at the tip of one index finger placed about a foot in front of the eyes, and then screen *each eye* successively and watch the unscreened eye. When the

working eye is covered the squinting eye makes an effort to fix the tip of the finger and moves towards the visual line; but the working eye remains quite stationary when the squinting eye is screened. If the working eye be watched behind the screen it will be seen to squint as soon as the affected eye "fixes" the object; this is known as *secondary squint*, and its direction and extent (unless the *primary squint* be due to paralysis) are the same as those of the original, or *primary squint.*

The Fourth Nerve.—The deep origin of this nerve is partly from the nucleus of the third in the aqueduct of SYLVIUS, and another nucleus below this point. It also communicates with the motor nucleus of the fifth. It passes through the outer wall of the cavernous sinus, and enters the orbit through the sphenoidal fissure, and then enters the orbital surface of the superior oblique. The function of this muscle is to turn the eye downwards and outwards. It may be **paralysed** by central disease, conditions causing pressure on the cavernous sinus, periostitis—simple, rheumatic, or syphilitic—of the sphenoidal fissure. Paralysis of the nerve gives rise to little sign, unless the patient looks below the horizontal level, when the paralysed eye lags behind the other, and is also twisted inwards by the inferior rectus, producing diplopia. The squint is paralytic and *convergent*, and, therefore, the images are not crossed *(Homonymous squint)*—*i.e.*, the right hand image belongs to the right eye, and *vice versâ*. As the eye is turned downwards, the false image is always below the true and leans towards it, and also seems nearer to the eye than the true one.

The Fifth Nerve.—The fifth nerve arises by two roots: the small, aganglionic motor root, arises from a nucleus just below the lateral angle of the fourth ventricle and from the grey matter at the sides of the aqueduct of SYLVIUS: the large, ganglionic sensory root arises from the nerve cells of the formatio reticularis of the pons and medulla. Only the first or ophthalmic division concerns the eye. It is the sensory nerve of the eyeball, and probably trophic in function as well; it also supplies the lachrymal gland, eyebrow, forehead, and nose. This explains why in deep-seated affections of the globe, such as iritis, there is pain over the eyebrow and down the side of the nose, and also the increased lachrymation. It also supplies the mucous membrane of the nose, and hence

irritation of this surface, as by snuff or the volatile oil of mustard, is often accompanied by increased lachrymation. The terminal branches of this division—the supra-orbital, supra-trochlear, and nasal—are frequently implicated in the disease known as *Herpes Zoster*, probably a form of neuritis. The **nasal branch** of this nerve takes a very remarkable course; it enters the orbit between the two heads of the external rectus, and between the two divisions of the third nerve, passes obliquely across the optic nerve to the inner wall of the orbit, and enters the anterior ethmoidal foramen. It then enters the cranial cavity, lies on the anterior part of the cribriform plate of the ethmoid, passes down through a slit by the side of the crista galli into the nose, where it divides into branches to supply the septum and the outer wall of the nose with common sensation. It gives *branches* to the ciliary ganglion, gives off the two long ciliary nerves to the eye, and an infra-trochlear twig to the lower part of the inner angle of the orbit; this latter branch supplies the skin, the conjunctiva, the lachrymal sac, and the caruncula lachrymalis. The ophthalmic division of the fifth appears on the face five times—(1) As the supra-orbital (2) the supra-trochlear, (3) the nasal, (4) infra-trochlear, and (5) the lachrymal. When this division of the fifth is paralysed there is loss of sensation in the various parts supplied, dryness of the eye from paralysis of the secretory fibres of the lachrymal gland, and also destructive inflammation of the cornea, partly from the loss of trophic influence, but also because foreign bodies do not produce sensible irritation or winking, and are, therefore, not expelled as foreign bodies, because they are not felt. The conjunctiva covering the lower eyelid is not affected, as this is supplied by a twig from the infra-orbital of the second division of the fifth.

The Sixth Nerve.—This nerve arises from a nucleus in the upper part of the floor of the fourth ventricle, beneath the fasciculus teres, continuous with the grey matter of the anterior horn of the cord, common to it and the portio dura of the seventh. It passes along the inner wall of the cavernous sinus close to the internal carotid artery, and enters the orbit through the sphenoidal fissure and supplies the external rectus. The result of paralysis of this nerve is internal squint (*convergent*). Being convergent *it is therefore homonymous, i.e.*, just as in the paralysis of the

fourth, the right hand image belongs to the right eye and *vice versâ*. There may also be contraction of the pupil in paralysis of this nerve, because some of the sympathetic fibres pass along with it to reach the radiating fibres of the iris. The patient will also feel giddy when the healthy eye is closed, as he has then false ideas of the position of external objects, because one judges of their position, to a great extent, by the degree of effort required to bring the eye to look at any given object. Also, if the patient close the good eye and strike at an object, he misses it by going too far to the outer side; and in like manner he cannot walk in a straight line, but takes a curve outwards as he attempts to reach any given point.

The causes of paralysis of the ocular nerves are very various. We have such causes as rheumatism, syphilis, and locomotor ataxy; pressure on the cavernous sinus, due to cerebral abscess, carotid aneurism or dilatation of the internal carotid. The third nerve passes between the posterior cerebral and the superior cerebellar arteries, and is, therefore, very apt to be compressed in old people where the arteries are diseased. Malignant tumours, aneurisms, and gummata at the base of the skull, also cause paralysis; very often one or more nerves being simultaneously affected. The common causes of *ophthalmoplegia externa* are locomotor ataxia, syphilis, diphtheria, and exposure to cold; if from syphilis, it is seldom very regular, one or more muscles usually escaping. Paralysis of accommodation is sometimes noticed after "*slight* sore throat," so slight as to be overlooked at the time.

The Sympathetic Nerve in relation to the eye.—In addition to its ordinary vaso-motor action, the sympathetic is the motor nerve to the **dilator pupillæ**, and also to MULLER's muscle—a layer of non-striped muscular tissue bridging across the sphenoidal fissure. The centre is probably situated in the medulla, but the fibres pass down the cord some little distance (*cilio-spinal region*), leaving it through the last cervical or the first two dorsal nerves, and entering the corresponding ganglia of the sympathetic trunk, up which they pass to the base of the skull, then along the plexus around the internal carotid artery (*carotid* and *cavernous* plexuses), pass along the sixth nerve, and then join the ophthalmic division of the fifth, forming part of its nasal branch, and thence through

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the long ciliary twigs of the nasal nerve to the radiating fibres of the iris. The stimulus for these fibres is the *absence* of light; they are also stimulated by the stimulation of other sensory nerves, *e.g.*, severe pain dilates the pupil, and also by the venous condition of the blood, as seen in the dilatation of the pupil in dyspnœa.

Mr HUTCHINSON, in his "Illustrations of Clinical Surgery," shows very beautifully the effect on the eye, produced by paralysis of the cervical sympathetic—(1) The eyeball is retracted within the orbit, probably from paralysis of the muscle of MÜLLER. (2) The pupil is contracted *in the shade*, although it responds to atropine; the paralysis simply prevents dilatation, but does not *cause* contraction. (3) The palpebral aperture is apparently narrowed from the slight drooping of the upper eyelid, probably from the paralysis of some smooth muscular fibres situated there, and also from the recession of the globe.

The Argyll Robertson Symptom.—By this is meant the failure of the pupil to react to light, while it still alters with accommodation. It is found in disease of the *cilio-spinal* region of the cord (a region extending from the third cervical to the second dorsal vertebra) and is often a very early sign of locomotor ataxia. Disease in this region involves the sympathetic fibres on their way from the medulla down the cord to make their exit at the last cervical and first dorsal nerves, and thence up to the pupil. These fibres being involved, the pupil is somewhat contracted and insensible to light, but still further contracts when a near object is looked at, though the strongest mydriatic will only produce a medium dilatation.

GLAUCOMA.

This disease is so named because of the greenish reflection observed in the interior of the eye. It is characterised, in the later stages, by great increase of the intra-ocular tension, so that the globe feels like a marble in hardness, with blindness or great limitation of the visual field. The **premonitory symptoms** are—(*a*) Greatly increased presbyopia, so that the spectacles must be changed often; (*b*) intermittent attacks of dimness of sight, like a fog in front of the eye—the patient seeing well enough in the morn*ing*, but from midday onwards the vision is occasionally obscured;

(*c*) dull aching in the eye, forehead, and temple; (*d*) the pupil is dilated, sluggish, or fixed; (*e*) prismatic halos are seen surrounding bright objects, such as a gas flame, the moon, etc. These symptoms may last for a variable time, and then an attack occurs, usually at night. There is intense sickness, vomiting, and severe neuralgic pain in the eye, forehead, side of nose, and temple; great lachrymation, almost complete blindness, injection of the conjunctival and sub-conjunctival vessels, and large tortuous veins are seen over the sclerotic, the corneal epithelium is uneven and dull in appearance, and there is a great increase of the tension; a shallow anterior chamber, concentric limitation of the field of vision, and cupping of the optic disc. The attack nearly always occurs in patients beyond middle life, who seem pale and unhealthy, and look as if they had suffered much; and it must be distinguished, in the first instance, from a "bilious attack." It is usually in hypermetropes, rarely in myopes; in persons predisposed to this condition, one must not use atropia, as it is very apt to bring on an acute attack, and will certainly aggravate an existing attack.

In chronic cases, the premonitory symptoms gradually pass into glaucoma without the onset of any acute attack. The fogs in front of the eyes may clear off for days or weeks, but by-and-by there are only remissions, and at length it passes into a well-marked state of glaucoma. There is a very acute form of glaucoma (*Glaucoma fulminans*) which may produce blindness in a few hours; but in ordinary acute cases blindness is not usually caused before eight or ten days.

All the above symptoms are to be explained by the increased intra-ocular tension. This causes the hardness of the globe; the dilated and sluggish pupil is due to the paralysis of the nerves of the iris by the increased pressure, and also because the lens is forced through the pupil; the shallow anterior chamber, because the parts behind are pushed forwards; anæsthesia of the cornea, due to paralysis of the first division of the fifth, from the great pressure; the distension of the subconjunctival and the sclerotic veins, because the pressure obstructs the flow through the vorticose veins; the intense pain is due to pressure on, and irritation of, the sensory nerves; the coloured spectra, from the pressure of

the vitreous humour on the retina irritating it; contraction of the field of vision, from the paralysing effects of pressure on the retina, which is thinnest at the periphery, and also because the vascular supply is obstructed; the cupped disc, because it is the point of least resistance, and it therefore yields to the increased pressure.

By the **ophthalmoscope** one may see—(*a*) Cupping of the optic disc, the cup is very deep, and extends right up to the edge of the disc; and over the edge, the vessels seem to dip with an abrupt curve, like a shepherd's crook, as the pressure has pushed them from the centre towards the periphery; (*b*) pulsation of the retinal arteries, especially if the globe be pressed upon; (*c*) the full and tortuous veins, and (*d*) there may also be small hæmorrhages.

The **cause** of the increased tension is doubtful. It has been supposed to be due to increased secretion of fluid from irritation of the fifth and inhibition of the vaso-motor branches of the sympathetic; or else due to the damming back of the fluid ordinarily secreted, by the closure of the spaces of FONTANA, from adhesion between the iris and the cornea at that angle, thus preventing permeation of fluid from the aqueous chamber through the canal of SCHLEMM, and thence into the veins.

Treatment.—The sulphate of eserine, or nitrate of pilocarpine, as palliative measures. **Radical**—(1) *Iridectomy* (see page 550), the best radical cure. (2) *Myotomy*, or the division of the ciliary muscle, as it has been supposed to be due to spasm of this muscle. (3) *Sclerotomy*, or division of the sclerotic at its junction with the cornea, to open up the spaces of FONTANA; prolapse of the iris is the usual result of this operation, but it may be tried after the failure of iridectomy. Before dividing the sclerotic, introduce eserine, to contract the pupil and so lessen the risk of prolapse; if done after iridectomy, of course this risk is removed.

CATARACT EXTRACTION.

The method usually adopted at the present day is GRAEFE'S modified linear, or something closely resembling it. **Instruments required** — (1) GRAEFE'S spring speculum; (2) a toothed fixing forceps; (3) GRAEFE'S narrow-bladed cataract knife; (4) a curved *and finely-toothed* iris forceps; (5) scissors, to snip off a portion

of the iris; (6) a curette or scoop; (7) a cystotome or pricker, to lacerate the capsule of the lens; and (8) a special scoop, to lift out the lens if necessary, as in a diseased eye, where pressure might be dangerous, or where the vitreous humour is very fluid or is beginning to escape at the corneal wound. The **patient** reclines on a table or couch with a support behind his head; the **Surgeon** stands most conveniently behind the patient's head, and should be ambidextrous, as it is more convenient to use the right hand for the right eye in making incisions, etc., and the left for the left eye. An assistant takes his stand on the patient's left side, opposite the Surgeon.

The **steps** of the operation are four—(1) The incision, (2) the removal of a part of the iris, (3) the laceration of the lens capsule, and (4) the expulsion of the lens.

The eye is rendered insensible to pain by means of a solution of cocaine, dropped in occasionally for ten minutes before the operation; it is then washed with a weak solution of corrosive sublimate (1 in 5000), and the spring speculum introduced and set. The Surgeon then fixes the eye by pinching up the conjunctiva close to the lower edge of the cornea. The knife is then introduced through the cornea and sclerotic junction, about half a line beyond the apparent edge of the cornea, and about a line and a half above its middle; the knife must be introduced perpendicularly till it has gone through into the anterior chamber, and then the plane of the knife must be made to correspond to the surface of the iris. It is then passed through a counter puncture, the edge turned upwards and forwards, and the knife made to cut its way out by slight sawing movements; the point of exit is just beyond the apparent edge of the cornea. The iris forceps is then introduced, the iris drawn out, and a little bit snipped off with the scissors. The pricker is next introduced, and the capsule lacerated in a crucial manner, beginning at the lower part. The scoop is now to be pressed against the lower edge of the cornea, when the lens will usually be extruded. The anterior chamber is then to be emptied of blood and lens matter, and the edges of the wound placed closely in apposition, taking care that neither lens matter nor any part of the iris is between its lips. A solution of eserine is then introduced to draw the iris away from the wounded region, the eye douched with

corrosive sublimate and then put up. The risks of iritis and prolapse of the iris are not so great as in the old flap, and by means of strict antiseptic precautions suppurative inflammation can usually be avoided.

IRIDECTOMY.

This operation consists in the removal of a portion of the iris. This may be **required** — 1. To form an *artificial pupil*, in cases where we wish—(*a*) to get a new opening after prolapse of the iris where the natural one is displaced; (*b*) to reopen or enlarge a pupil obstructed by previous inflammation; and (*c*) to displace the pupil towards a transparent part of the cornea, or opposite a clear part of the lens, in cases where the cataract is stationary and central. 2. To influence the course of some diseases as — (*a*) Glaucoma, (*b*) recurrent gouty iritis, (*c*) irido-choroiditis, (*d*) purulent iritis, (*e*) advancing staphyloma of cornea, and (*f*) ulcer of the cornea with pus in the anterior chamber (*hypopyon keratitis*). 3. For occlusion or exclusion of the pupil after iritis. 4. Sometimes preliminary to cataract extraction, in order to ripen the cataract.

The position and preparation of the patient, and the position of the Surgeon and his assistant are the same as in cataract extraction. **Instruments required**—(1) A spring speculum, (2) fixing forceps, (3) curved scissors with elbow bend, (4) fine-toothed iris forceps, and (5) a bent triangular keratome—like a broad needle. The opening for artificial pupil must be made where the media are clearest; if a choice be allowed, then the lower and inner part should be chosen, as this will cause least deformity and also be in the most useful position. The globe being fixed, an incision is made through the cornea and sclerotic junction at the part where the artificial pupil is to be; it should not be all in the cornea, lest the cicatrix contract and alter its curvature. The iris forceps is then introduced closed, the iris seized and drawn out, and a little bit snipped off with the scissors, forming a pupil something between square and round in shape. The iris should be grasped at the pupillary border, lest a button-hole be made in it, and then cut off with a single snip.

In **Glaucoma** a GRAEFE's cataract knife is used and a good large *incision made* (resembling that for cataract, but not quite so large,)

at the cornea and sclerotic junction, so as to open up, if possible, the angle between the iris and the cornea, where the spaces of FONTANA lie. The portion of the iris removed in this case is always at the *upper part*, because the disfigurement is less and the optical defect also less, as it is covered by the upper lid, since the operation in this case is not performed for the purpose of securing an artificial pupil, but for curing the disease. A *large* bit of iris is removed; it must be pulled well out and cut away from the *very ciliary edge*. It is done during the acute stage of the disease. When for artificial pupil, only after the condition has become chronic or subsided altogether.

OPERATION FOR STRABISMUS.

The patient is prepared as before, but probably had better be under the influence of chloroform, or cocaine may be injected deeply. The Surgeon and assistant stand as before. **Instruments required** are—(1) A spring speculum, (2) straight, blunt pointed scissors; (3) a toothed fixation forceps, and (4) a strabismus hook. The operation is performed very often more for appearance than to improve vision, as the patient has probably become accustomed to suppress the image of the squinting eye.

1. **The Subconjunctival, or English Method.** A fold of the conjunctiva is pinched up *below* the level of the insertion of the tendon to be divided, and then incised with the straight blunt-pointed scissors. The capsule of TENON is now exposed, and must be divided by thrusting in the point of the scissors below the conjunctiva. The probe-pointed strabismus hook is then passed into the wound, with the concavity downwards and the point backwards, through the opening in the conjunctiva and capsule, and carried along the surface of the sclerotic; the concavity of the hook is then turned upwards, its point being kept close to the sclerotic, and slipped between the tendon and the globe. The hook is then pulled forwards, the tendon raised off the surface of the globe and divided by the scissors, between the hook and the globe; make sure that all the fibres are divided by passing the hook back and then drawing it forwards again, when it will slip forwards beneath the conjunctiva as far as the edge of the cornea if the tendon is completely divided.

2. **The Direct, or Continental Method.**—A vertical incision is made right over the tendon close to the cornea. By this method the tendon can be *seen*, so that the Surgeon can see what he is doing, and can make certain of dividing all the fibres. In dividing the capsule of TENON, pass the scissors towards the inner canthus and free it well there, so as to lessen the risk of unsightly retraction at that part. A horse-hair suture requires to be introduced into the conjunctiva to bring its edges together, and the wound probably does not heal so readily as in the other method.

Little after treatment is required. The eye is tied up for a few hours, say, till bedtime, when everything is removed; for a day or so longer the patient may wear a shade and remain in a darkened room, but the sooner the eye is brought into use the better, so that the tendon may be moulded while it is yet plastic.

READJUSTMENT OR ADVANCEMENT.

This operation consists in bringing forwards to a new attachment the tendon of a rectus — usually the internal, sometimes the external which has become attached too far back after a previous tenotomy, or has become weakened, as in myopia. The **instruments** required are—a stop speculum, straight scissors with blunted points, a toothed fixation forceps, a strabismus hook, and two or three double-needled sutures.

Critchett's Operation

1. Make a vertical incision, exposing the internal rectus, about one-sixth of an inch from the edge of the cornea.
2. Divide the tendon in the usual way.
3. Pass the two or three needles from within outwards, through the flap formed by the tendon, fascia, and conjunctiva, at some distance from its free edge.
4. Shorten this flap by cutting off its free edge.
5. Pass the other ends of the sutures from within outwards, through the fascia and conjunctiva, close to the edge of the cornea, taking as broad a hold as possible.
6. Divide the external rectus in the usual way, and introduce a silk traction suture at the outer side of the eye by which it can be drawn inwards.

7. Tighten the tendon sutures first introduced.
8. Fasten the traction suture to the nose by plaster, pulling the eye inwards as far as possible. This suture soon cuts its way out: the tendon sutures are left in for a week or so.

Prince's Operation.—For this operation it is better to have PRINCE'S special advancement forceps, and a special curved and handled needle with the eye in point is sometimes necessary, though, as a rule, the usual curved needles are quite sufficient. We also require one double-needled suture, one single-needled suture, as well as the ordinary strabismus instruments.

1. Expose the internal rectus as in last operation.
2. Hook it up on strabismus hook, or grasp it with special forceps.
3. Pass sutures through the tendon, using the double-needled suture—passing both needles from behind forwards, through the rectus, its sheath, and the conjunctiva. This is the "*loop suture.*"
4. Divide and remove part of the tendon.
5. Divide the external rectus in the usual way.
6. Pass a suture through the conjunctival and subconjunctival tissue near the edge of the cornea, opposite the tendon to be advanced. This suture should be passed in the vertical direction, and is the "*pulley suture.*"
7. Tie this suture tightly, making it include one of the ends of the suture through the tendon. This suture is to act as a pulley, or *point d'appui*, by means of which the tendon is pulled forwards by the other suture.
8. Tie the two ends of the suture through the tendon, pulling the tendon tightly up against the former suture.
9. Bring the edges of the divided conjunctiva together by means of a suture.

Brudenell Carter's Operation.—By this operation the sheath of the optic nerve is opened for the relief of pressure. It is said that fluid in the arachnoid space is forced through the optic foramen, between the two coats of the optic nerve, in certain cases where the intra-cranial pressure is increased. The fluid passes along the nerve up to its insertion into the eyeball, but there is

is stopped because of the sclerotic ring; the pressure thus caused produces strangulation of the contents of the optic sheath—nerve fibres and vessels—causing disturbance of vision and secondary atrophy of the optic nerve.

The nerve is exposed and reached from the outer side. The conjunctiva and subconjunctival tissues are divided, the external rectus hooked up, and sutures inserted at two points, and the muscle divided between them. TENON'S capsule is next divided, the intervening tissue scratched through, and the optic nerve exposed; after which the sheath is pinched up and incised, when some fluid will escape. The two ends of the divided rectus are then tied together by the sutures previously introduced, and the conjunctival wound closed.

EXCISION OF THE EYE.

This may be rendered necessary for—1. "*Sympathetic*" *ophthalmia* (ophthalmitis), usually due to some wound, accidental or operative, in the ciliary region of the eye—a zone about a quarter of an inch wide surrounding the cornea, often spoken of as the "*dangerous zone*" of the eye. 2. In cases of wounds, where the vision is destroyed and the foreign body cannot be found. 3. In pan-ophthalmitis. 4. In general staphyloma of the globe, or large staphyloma of the cornea. 5. For the removal of tender irritable stumps. 6. Tumours of the interior, *e.g.*, glioma of the retina, or melanotic sarcoma of the choroid.

Instruments required—(1) Spring speculum; (2) blunt-pointed scissors curved on the flat; (3) fixation forceps; (4) strabismus hook; (5) sponges, lint, and wool; (6) ice-cold water; (7) styptic, such as perchloride of iron; (8) fine needle and silk sutures; and (9) chloroform, etc. The **operator** may most conveniently stand behind the patient. Introduce the speculum and divide the ocular conjunctiva all round close to the edge of the cornea, beginning at the upper part, with the scissors. Then raise up the conjunctiva and divide TENON'S capsule also with the scissors, and then with the strabismus hook, hook up and divide the recti one after the other, capsule and all; the superior oblique may also be divided on the hook, but the inferior is left for the present. Now make *the eye start* forwards by pressing the spring speculum behind the

globe, and then pass the curved scissors from the outer side, round the sclerotic, and divide the optic nerve and remove the globe by dividing the inferior oblique, and any remaining soft tissues. Then at once plug up the opening by compresses of cotton wool wrung out of some cold antiseptic; this is for the purpose of controlling hæmorrhage by pressure. The cut edges of the conjunctiva may or may not be brought together by sutures, according to the inclination of the operator. Pressure must be kept up for six or eight hours by means of sponges or cotton wool. If this operation be performed for malignant tumours of the orbit (sarcomata) the whole contents must be cleared out; for simple conditions a less radical method will suffice, the chief thing to be kept in mind being that whatever else is left, the corneal tissue must be all removed.

Structures Divided.—The ocular conjunctiva; the capsule of TENON; the four recti; the two obliques; the ciliary arteries and nerves; the optic nerve with the arteria centralis retinæ; branches of the third and fifth nerves; and twigs of the ophthalmic artery and vein.

INJURY TO EYE.

The **possible results** of a blow on the eye are:—

1. Temporary paralysis of accommodation from concussion.
2. Commotio retinæ, and possibly also detachment of the retina.
3. Effusion of blood into the anterior chamber, or into the vitreous.
4. Superficial septic ulcer of cornea, with pus in the anterior chamber.
5. Dislocation of lens.
6. Detachment of the iris from its ciliary connections (the zonule of ZINN).
7. Rupture of the lens capsule and traumatic cataract from the lens imbibing the aqueous.
8. Inflammation of the iris and ciliary processes.
9. Growth of a sarcoma.
10. Fissure through the optic foramen, causing blindness from injury to the optic nerve, which is followed at a later date by atrophy of that structure.

11. Cataract, from injury to the frontal or infra-orbital nerves, setting up a neuritis that spreads backwards and affects the nutrition of the globe.
12. Rupture of the sclerotic, usually about a quarter of an inch behind the cornea; the choroid may also be ruptured.
13. Hæmorrhage into the space between the lamina supra-choroidea and the lamina fusca.

A curious train of **Eye Symptoms** are often observed in the disease known as **Locomotor Ataxia,** a disease consisting in chronic inflammation, followed by sclerosis of the postero-external tract of the cord (BURDACH'S), spreading to the postero-internal column and probably to the direct cerebellar tract as well. The symptoms observed are—(1) The ARGYLL ROBERTSON symptom (see page 546); (2) *temporary* paralysis of the various ocular nerves with accompanying symptoms; (3) marked myosis, the pupil being often contracted to a pin point; (4) frequently unequal size of the pupils; (5) colour blindness; and, lastly, (6) atrophy of the optic nerve and gradual loss of sight.

A remarkable train of symptoms is frequently observed to follow "**Concussion of the Spine,**" *e.g.*, in railway injuries; we may find any one of the following five:—(1) Asthenopia; (2) amblyopia; (3) loss, or failure, of the power of accommodation; (4) irritability of the eye and photopsia, from neuro-retinitis; and, lastly, (5) atrophy of the optic nerve and gradual loss of sight.

CHAPTER XXVIII.

THE EAR.

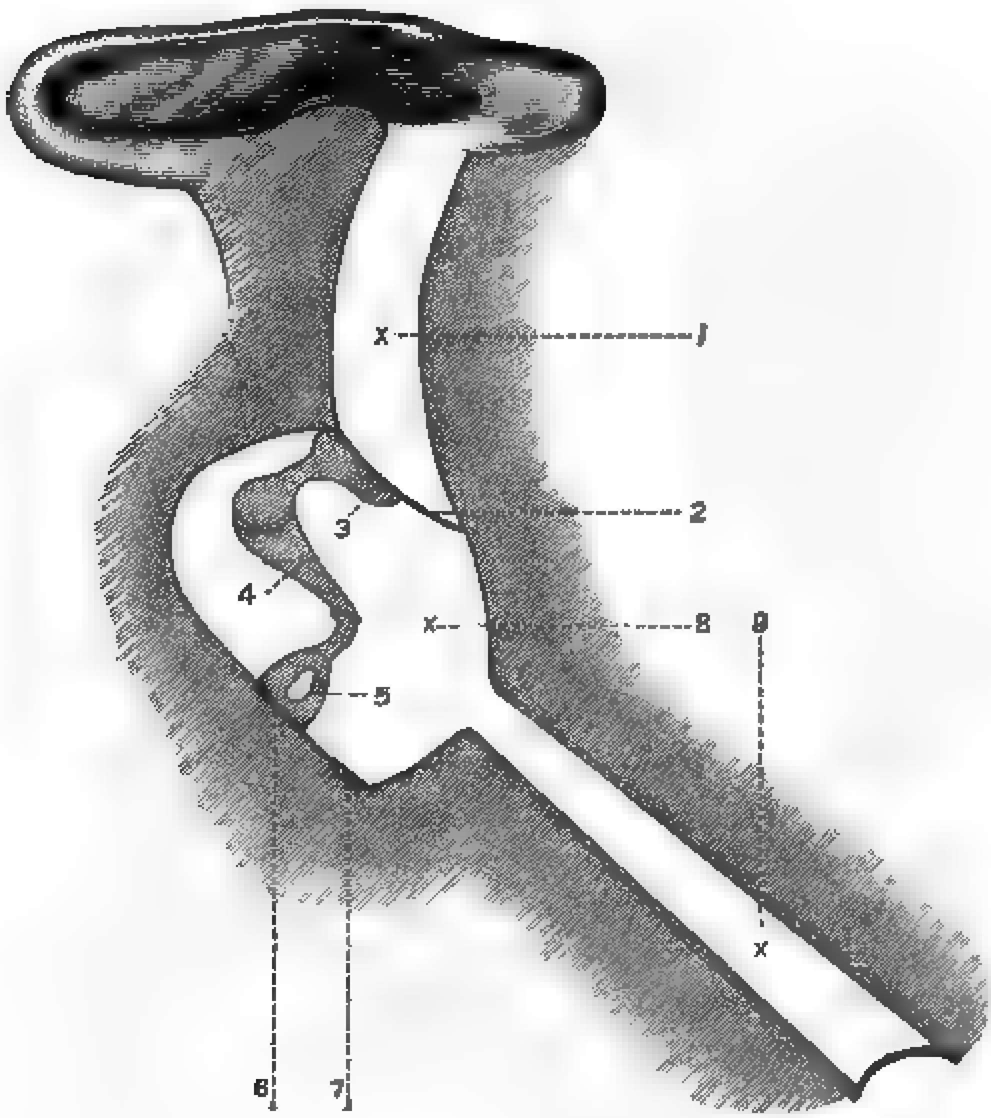
EXTERNAL AUDITORY MEATUS.

THIS canal is about an inch and a quarter in length; the lower wall is the longest on account of the oblique direction of the membrana tympani, which forms an angle of forty-five degrees with the horizon in the adult. In the child, however, the membrane is more nearly horizontal, forming only an angle of ten degrees with the horizon; but as age advances this gradually increases. The meatus passes obliquely forwards and inwards, and is curved upon itself, the concavity pointing downwards, so that its floor is convex; it is also curved a little forwards. Its shape is oval, with the long axis vertical, and it is narrowest about the middle, and, therefore, the ear speculum should not be introduced beyond this point. Rather less than one-half its length is formed of cartilage, the rest of bone. In young children, however, there is practically no bony part, and in them, therefore, the meatus is very short. In examining the membrana tympani, by means of the speculum and mirror, the pinna or auricle, should be pulled upwards and backwards in order to straighten the meatus as much as possible. In health, the membrana tympani is transparent, *smooth and shining*, and has a slate-blue colour, or delicate bluish grey, and it is concave from the outside; from its transparency it is possible to see serous collections in the middle ear through it. Besides seeing the membrane we also see the handle and short process of the malleus (which are situated between the outer and middle layers of the membrane) and that appearance known to aural surgeons as the "triangle of light," with its apex at the end of the handle of the malleus, an appearance due to the peculiar curvature of the membrane, the rays from the two sides crossing each other at the anterior and lower

part. The handle of the malleus runs from above downwards and backwards to a little below the centre of the membrane. From the short process there are two folds, one passing forwards, and the other backwards, and the part of the membrane above this is very thin, consisting only of cutaneous and mucous layers; this part is called Shrapnell's membrane.

Fig. 118.

The Ear.



1. External Auditory Meatus.
2. Membrana Tympani.
3. Malleus. 4. Incus.
5. Stapes.
6. Membrane shutting off the *Tympanic Cavity* from the Vestibule.
7. Membrane in the Foramen Rotundum, shutting off the Tympanic Cavity from the Scala Tympani of the Cochlea.
8. Tympanic Cavity.
9. Eustachian Tube.

Structure of the Membrane.—It consists of three layers—(1) The outer, or cuticular layer, a continuation of the skin of the meatus. (2) The internal, or mucous layer, which is continuous with the mucous membrane of the tympanic cavity; in a fold of this layer the chorda tympani nerve lies concealed. (3) The middle, or fibrous layer, consisting of connective tissue fibres arranged both radially and circularly—the *radial* are the more numerous, and radiate from the point of attachment of the handle of the malleus; the *circular* form a dense ring near the circumference, and are lodged in a bony groove which is deficient at the upper anterior part (*notch of Rivinus*). The layer itself is also defective above, and here, therefore, the membrane is only composed by the cuticular and mucous layers; this part is known as the *membrana flaccida*, or SHRAPNELL's membrane.

Nerves of the meatus. The principal nerves are derived from the *auriculo-temporal*, which is a branch of the third division of the fifth nerve, and supplies the outer layer of the membrana tympani; the *great auricular* from the cervical plexus, and the *auricular branch* of the vagus (ARNOLD's nerve). These nerves and their communications explain the occasional peculiar results of irritation of the external auditory meatus—such as coughing and sneezing from irritation of ARNOLD's nerve, and the auriculo-temporal nerve respectively, and yawning from irritation of the auriculo-temporal nerve, the impulse passing to the muscles that open the jaws. The **vessels** of the meatus are derived from the posterior auricular, internal maxillary, and temporal arteries. **Incisions** through this membrane should be made at the lower and posterior part, as by so doing we escape the ossicles, the chorda tympani, and other important structures. Just as in other serous membranes, the early signs of inflammation are congestion and loss of polish, and it also becomes less concave from the accompanying Eustachian obstruction.

The Cysts of the Auricle.—We may find—(1) Simple serous cysts; (2) sebaceous cysts; (3) the traumatic hæmatoma of foot-ball players; (4) the hæmatoma of lunatics (*Hæmatoma auris*, or Othæmatoma)—the hæmatoma consists of an effusion of blood between the cartilage and the perichondrium. From its frequent occurrence in lunatic asylums, it has been termed "**insane ear.**" (5) We may also find abscesses; and, lastly, (6) dermoid cysts.

Supernumerary Auricles are occasionally found. They are sometimes represented by small tags of skin near the pinna; or again, they may be found in the neck, in association with branchial fistulæ. The pinna is first indicated in the embryo by six small tubercles, which arise on each side of the hyo-mandibular cleft. When any of the tubercles fail to coalesce the result may be congenital fistulæ, or supernumerary auricles. Sometimes also bits of epithelium become buried during their coalescence and form the germs of dermoid cysts.

THE MIDDLE EAR OR TYMPANUM.

This is a small six-sided cavity, somewhat compressed from side to side, situated in the substance of the temporal bone, and containing air. It communicates with the pharynx, by means of the Eustachian tube. It is placed immediately above the jugular fossa; in front is the carotid canal, with the internal carotid artery; behind are the mastoid cells and the internal jugular vein; externally the membrana tympani and external auditory meatus, and internally the labyrinth.

Boundaries.—1. The **roof** is a thin plate of bone separating the cranial from the tympanic cavity; the bone is only separated from the temporo-sphenoidal lobe by the dura mater.

2. The **floor** is formed by the meeting of the outer and inner walls, and is immediately above the jugular fossa; in the floor is a small aperture for the entrance of JACOBSON'S nerve (from the glosso-pharyngeal).

3. The **outer wall** is the membrana tympani. At the lower part of this wall there are three openings—the *Glaserian fissure,* which gives passage to the laxator tympani muscle, the tympanic vessels, and lodges the processus gracilis of the malleus; and the *iter chordæ posterius et anterius,* being the apertures of entrance and exit of the chorda tympani nerve. The *iter chordæ anterius* is the beginning of the canal of HUGUIER. The chorda tympani is the nerve of taste to the anterior two-thirds of the tongue, and passes across the cavity from back to front, close to the outer wall, between the handle of the malleus and the long process of the *incus,* being invested by a fold of the mucous membrane forming

the most internal layer of the membrana tympani. It is easy to understand, therefore, how this nerve may be implicated by disease of the middle ear, and its function consequently stimulated, causing an excessive flow of saliva, or altogether destroyed.

4. The **inner wall** is vertical, and looks almost directly outwards. On this wall, note—(*a*) The *Fenestra ovalis*, a depression which leads to the vestibule, but which is closed by a membrane similar in structure to the membrana tympani; the depression is occupied by the base of the stapes. (*b*) The *Fenestra rotunda*, a depression which leads to the scala tympani of the cochlea. It is also closed by a membrane resembling the tympanic membrane in structure. (*c*) The *Promontory*, a hollow prominence formed by the first turn of the cochlea; it is placed anteriorly, and between the two fenestræ, and is grooved by the nerves of the tympanic plexus. (*d*) The rounded eminence of the *Aquæductus Fallopii*, which lodges the facial nerve. (*e*) The *Pyramid;* it contains the stapedius muscle, and has a small opening at its apex for the exit of the tendon of that muscle; there is also a minute canal for the nerve to the stapedius, from the facial.

5. In the **Posterior wall** are the openings of the mastoid cells, one large (the mastoid antrum) and several smaller openings; the openings are near the roof of the cavity.

6. In the **Anterior wall** we find—(*a*) The canal for the tensor tympani; (*b*) the processus cochleariformis, a process of bone which separates the above from (*c*) the Eustachian tube, which is the lower and larger of the two openings. By this tube the middle ear communicates with the nasal part of the pharynx.

The external auditory meatus, the tympanic cavity, and the Eustachian tube, are all **developed** from the upper part of the *first branchial cleft.*

The **arteries** of the tympanum are—(1) Tympanic branch of the internal maxillary, which enters the tympanum through the Glaserian fissure; (2) the stylo-mastoid branch of posterior auricular, which enters at the stylo-mastoid foramen; (3) petrosal branch of meningeal, entering through the hiatus Fallopii; (4) a branch from the ascending pharyngeal, passing up the Eustachian tube; and (5) a small twig from the internal carotid artery, entering through the anterior wall of the cavity. Its **Nerves** are—

(1) The tympanic branch of the glosso-pharyngeal (JACOBSON'S nerve), which enters through an aperture in the floor of the cavity, and is distributed to the Eustachian tube, foramen ovale, and foramen rotundum, and communicates with (2) twig from the carotid plexus, (3) twig from the great superficial petrosal, and (4) sends a twig to join the lesser superficial petrosal. It is thus distributed to *three* parts, and has *three* communications.

EUSTACHIAN TUBE.

The Eustachian tube is a canal from one and a half to two inches in length, and its direction is downwards, forwards, and inwards. It consists of—(*a*) An osseous part about half-an-inch in length, situated in the temporal bone; it begins in the anterior wall of the tympanic cavity, and is directed downwards and forwards; and (*b*) a cartilaginous part about an inch in length, of triangular shape, and composed of yellow elastic fibro-cartilage. The open part is below, and it is completed by a fibrous membrane and a layer of voluntary muscle; it ends in a trumpet-shaped mouth nearly on a level with the inferior meatus of the nose. It is lined by ciliated epithelium, the cilia of which lash downwards; it is usually closed, but is opened at the moment of swallowing by the dilator tubæ, levator palati, and salpingo-pharyngeus muscles. The mucous membrane is supplied by the glosso-pharyngeal and the second division of the fifth; the muscles by the facial and the third division of the fifth. The blood-vessels are derived from the internal maxillary, the ascending pharyngeal, and the internal carotid. Its use is to get rid of secretions from, and to ventilate the tympanic cavity. By its means the pressure of air in the cavity is kept the same as in the external auditory meatus, so that the pressure on each side of the membrane is the same, a condition necessary for the clear perception of sound waves.

The open trumpet-shaped mouth of this tube is situated on a level with the posterior extremity of the inferior turbinated bone. According to TILLAUX, the opening is about half-an-inch below the basilar process; half-an-inch in front of the posterior wall of the pharynx; half-an-inch behind the posterior extremity of the inferior turbinated bone; and half-an-inch above the soft palate. *In this way* the nasal part of the pharynx of one side may be

regarded as a little box one inch square, and in the centre of its outer side is placed the opening of the tube. Immediately behind the orifice of the Eustachian tube is a depression known as the fossa of ROSENMÜLLER, into which the point of the catheter may be inadvertently slipped. Obstruction of the tube gives rise, if not to deafness, at least to considerable impairment of hearing, from indrawing and rigidity of the membrana tympani, and it will be necessary to adopt some means to get rid of the obstruction.

1. This may be attempted by **Valsalva's Method,** directing the patient to hold his nose between the finger and thumb of one hand, close the mouth, and expire forcibly. If at the same time the patient is directed to swallow, the effect will be all the more evident.

2. **Politzer's Method.**—This method for forcing air up the Eustachian tube takes advantage of the physiological fact, that during deglutition the opening from the mouth into the upper part of the pharynx and posterior nares is closed, and also at the same time the Eustachian tube is opened by the dilator tubæ or tensor palati, and by the Salpingo-pharyngeus. Every time one swallows it is possible to hear a "click" in the ear due to the air being forced up the Eustachian tube and impinging against the membrana tympani, and this is rendered much more evident if at the same time the nostrils are closed by grasping the nose between the finger and thumb. By these means we have really an air-tight chamber, and if any of its walls are squeezed or forced inwards, or if more air be driven in, the air being practically incompressible is driven in the direction of the least resistance, *e.g.*, up the Eustachian tube. The patient is directed to take a mouthful of fluid, and at a given signal from the operator, to swallow it. The operator introduces the end of a tube (the other end of which is in communication with a small reservoir of air) into one nostril, and closes the nostrils with the finger and thumb of one hand, while with the other hand he grasps the air-bag. He then directs the patient to swallow, and as he does so, the operator projects into the nostril a quantity of air, which increases the pressure, and some of it passes up the Eustachian tube into the tympanum. It will be seen that this method resembles VALSALVA's very closely, only by means of the air-bag greater pressure can be brought to bear upon any obstruction

that may be present in the tube. Instead of taking a mouthful of water other plans may be adopted, such, for example, as asking the patient to say "Huck" (Gruber), or a still more convenient plan of simply directing the patient to puff out the cheeks (Holt). In cases where the patient, or Surgeon, is doubtful whether the air has or has not entered the cavity, one of the patient's ears must be connected with that of the Surgeon by a flexible rubber tube. In this way the Surgeon will be able to tell whether the air enters the cavity in the usual amount and with the usual force, or feebly, or not at all, according to the presence or absence of stenosis of the Eustachian tube; he will also hear in this way whether there are superadded sounds, such as bubbling or crackling from the presence of fluid in the cavity, or whether a whistling sound is heard, due to the air passing right through the membrane and tube into the Surgeon's ear, from the presence of a perforation in the membrana tympani.

3. If the above means fail, then recourse must be had to the **Eustachian Catheter.** The catheter may be made of various materials, hard rubber, vulcanite, silver, etc. It is curved at the end which is passed into the tube; at the other end it is expanded so as to fit the nozzle of the air-bag, and also has a ring, which corresponds to the concave side of the curve at the point, so that it thus indicates the position of the point of the instrument when it is lost to sight. The Surgeon connects his ear with the diseased ear of the patient by means of the flexible tube. The patient sits facing the light, with his head leaning slightly backwards, the mouth open and breathing easily. The Surgeon stands in front of the patient, with the air-bag under his left arm, and with his left hand slightly raises the tip of the patient's nose, and with the right passes the catheter along the floor of the inferior meatus, with its point downwards, and pushes it gently onwards till the posterior wall of the pharynx is reached. After this, the method recommended by Dr McBride, is to turn the point of the instrument inwards, towards the median line, through a quarter of a circle, and then withdraw it till the curve at the point is caught by the nasal septum, when it is again rotated, through half a circle this time, so that its point is brought at right angles to the lateral wall of the pharynx, and then, if it is not in the tube, a little

pressure of the beak outwards, produced by moving the other end of the tube inwards, will cause it to enter the orifice. To place the point of the instrument into the exact axis of the tube, the ring at the outer end should point to the outer canthus of the corresponding eye. It is necessary to pass the catheter along the *floor* of the nose, as otherwise it might very easily be passed into the middle meatus.

THE INNER EAR OR LABYRINTH.

The **osseous** part simply consists of certain cavities scooped out in the petrous portion of the temporal bone. The whole is lined by a thin periosteal membrane, and filled with peri-lymph *(Liquor Cotunnii)*. The membranous parts are much smaller than the osseous, being contained in the osseous parts, and surrounded by the peri-lymph. The **membranous labyrinth** consists of a system of tubes and bags, which are all connected together, forming a completely closed system, the cavities of which have no direct communication with the osseous cavities; anteriorly is the cochlea, posteriorly the semi-circular canals, and between the two is placed the vestibule, which consists of the utricle and saccule. The saccule is connected with the scala media of the cochlea by the canalis reuniens, and to the utricle by the ductus vestibuli; the three semi-circular canals are also connected with the utricle. The membranous labyrinth contains endo-lymph *(Liquor Scarpæ)*.

The **Nerve of Hearing** (*auditory* or *portio mollis* of seventh) is distributed to the different parts of the internal ear. The *vestibular* division is distributed to the utricle and saccule, and to the three ampullæ of the semi-circular canals, where it can be traced to peculiar elevations known as the cristæ accousticæ. The portion supplying the utricle and saccule probably end in the hair cells of the cristæ accousticæ, with their otoliths and jelly, the whole being similar to the structures forming the entire hearing apparatus of the invertebrata; this part enables us to appreciate the *sense* of sound, whether low or loud—absolute silence or noise—but does not discriminate the quality. The part passing to the semi-circular canals ends in a similar manner, and seems to be concerned in the co-ordination of muscular movements, probably because the fibres convey to the brain impulses that, in some way, give us correct

notions of our equilibrium or relation to external objects. In all probability, therefore, it is this part of the nerve that is overwhelmed, and unable to grasp the situation, for the time being, when an individual is sea-sick. If this be so, it will be at once evident how useless *every* drug must be, and how effective *any* drug may be, and this may explain the curious circumstance that every new drug in turn is discovered at last to be *the* remedy for sea-sickness, and hailed with gladness by a suffering humanity. The *cochlear* part is distributed to the scala media of the cochlea, being believed to end there in the "organ of CORTI." This part of the nerve enables us to discriminate the *quality* of sounds, giving rise in the mind to a distinct *musical* impression; and the curious part is that one can distinguish a great many musical sounds *at the same time.* Sound waves can reach the auditory nerve in two ways—(1) through the external auditory meatus, membrana tympani, and ossicles, to the peri-lymph, and thence to the endolymph; or (2) through the bones of the head, and, possibly, also the bones of the trunk, and hence the origin and use of the Audiophone, whereby a deaf person (provided the nerve of hearing is not destroyed) is enabled to hear, to a certain extent, by placing it against the teeth.

EXAMINATION OF THE EAR.

The hearing power may be first tested by ordinary speech, whispering, or the ticking of a watch. Deafness may be due to faults in the sound-perceiving or the sound-conducting parts of the ear. The **internal ear,** where the sound-perceiving part is placed, is beyond our reach, but the condition of the nerve can be tested by applying the tuning-fork to the middle of the forehead or to the teeth. In health, the fork should be heard in both ears with equal intensity. If, then, it is heard well in both ears, the fault cannot lie with the auditory nerve, and the cause of the deafness must be sought for in the sound-conducting part (the external and middle ear). In cases where the fault lies in this part of the organ, then, curiously enough, the tuning-fork is heard best in the deafer ear. When the tuning-fork is applied to the forehead or teeth, the vibrations of the bones of the head conduct the sound waves to *a healthy* cochlea, even when the aerial vibrations are prevented

from passing; but if no sound is perceived when thus applied, it shows that the nerve of hearing is destroyed, or at least functionally useless.

External Ear and Membrana Tympani.—This part may be viewed by the unaided eye, by the mirror alone, by the mirror and speculum, and tested by the tuning-fork. In examining the membrane, any change of colour can be noted, whether it is red, or has lost its glossy appearance; also whether it is concave and shows more clearly the various processes of bone in relation with it, from deficient internal pressure, or whether it bulges outwards from accumulation of fluids in the tympanic cavity, from obstruction in the Eustachian tube, or the results of inflammation. Also whether it is movable, as by VALSALVA's method, or by SIEGLE's Pneumatic Speculum, or whether it is perforated, or entirely or partially hidden by wax. The meatus is often attacked by small boils, which are really circumscribed acute inflammations of the parts; they cause great pain and suffering, and form one variety of acute earache. Occasionally the inflammation is diffuse, and when it attacks the bony part it resembles an acute periostitis in its symptoms and course; this also would probably be called acute ear-ache. "**Wax**" impacted in the ear is often a cause of sudden deafness, either from the mass being displaced so as to block up the canal completely, or from the entrance of water making it swell up so as to cause a complete block. The presence of wax may also cause severe tinnitus, or sounds in the ear, fits of coughing from irritation of ARNOLD's nerve, or sneezing or persistent yawning from irritation of the auriculo-temporal nerve. The wax should be softened by putting in a few drops of a warm weak solution of bicarbonate of soda (five grains to the ounce) two or three times a day for a few days, and then syringe out the ear with warm water. The fluid is injected parallel with and along the upper wall; this is sometimes accompanied with vertigo and faintness from irritation of the membrana tympani. The ear must then be dried out with cotton wool, and a plug of dry wool worn for the rest of the day.

Middle Ear and Eustachian Tube.—Much information can be gathered from the examination of the membrana tympani as to the condition of the middle ear. As it is transparent one may be able to see fluid in the middle ear through it. Also note whether it is

thickened from fibrous changes in the middle ear, convex from accumulations in that cavity, or concave from an obstruction in the Eustachian tube, whereby the air has become rarefied, or absorbed. The other avenue of information as to its condition is to examine the throat, as disease of the middle ear often begins in the throat and passes upwards along the Eustachian tube to that cavity. Any condition therefore capable of setting up acute naso-pharyngeal catarrh may also produce acute inflammation of the middle ear; it is often secondary to a cold in the head, or sore throat, either simple, or after measles or scarlet fever. Further, obstruction of the tube is very often due to hypertrophy of the pharyngeal tonsils *(adenoid vegetations of the naso-pharynx)* blocking its orifice. Then, by some of the means already described, the Surgeon should examine whether the tube is patent or not.

Adenoid Vegetations of the Naso-Pharynx are common in scrofulous children, and especially so in cold damp climates and dwellings. Besides being partially deaf the child usually keeps the mouth open to breath through, and has a very characteristic expression of face; he snores loudly during sleep, and in some cases there may be difficulty of breathing from the co-incident hypertrophy of the tonsils. The voice is peculiarly altered, the letters m and n being pronounced like b and d, no, no, sounding like dodo, and words beginning with com and con like cob and cod, as in common and conversation. There is also a characteristic flattening of the nostrils, as well as noises in the ears, and slight discharge of blood into the pharynx in the morning, with troublesome morning cough and sanguineous expectoration, and sometimes also vomiting. It is very often accompanied by "chronic atrophic rhinitis." The *pharyngeal tonsils* stretch across the back of the pharyngeal cavity, between the orifices of the two Eustachian tubes (KÖLLIKER).

Chronic Suppuration of the Middle Ear is usually caused by inflammation spreading up from the throat *(naso-pharyngeal catarrh)*, and a large number of cases usually date their commencement from an attack of measles or scarlet fever—probably again from the inflammation spreading up from the throat. This is the origin of the "running ear," and when examined the membrana tympani is usually found to be perforated; the condition

is usually bi-lateral. The acute stage of this condition forms the acute earache of childhood in a large proportion of cases; it should be watched for *during* the course of an attack of measles or scarlet fever as well as afterwards. Besides perforation, other and more serious **complications** are apt to follow suppuration of the middle ear—such, for example, as inflammation of the mastoid cells, caries of the bone, facial paralysis, inflammation of the membranes of the brain, local or diffuse, and simple or suppurative, especially diffuse purulent arachnitis, pyæmia, granulations and polypi blocking up the meatus, inflammation of the brain, cerebral abscess, perforation of the internal carotid artery, thrombosis of the lateral sinus or internal jugular vein, and, lastly, destruction of the chorda tympani nerve.

To explain these phenomena one has only to keep in mind the **relations of the tympanic cavity.** On the **inner wall** lies the facial nerve, covered only by a thin crust of bone; and immediately beyond this wall lies the internal ear, hence inflammation and suppuration may be readily set up in the labyrinth, and may possibly reach the cerebellum, or medulla oblongata, through the internal auditory meatus. On the **outer wall** the chorda tympani nerve lies in a fold of mucous membrane. The **roof** is very thin, and inflammation can readily pass through the bone to the dura mater and then to the brain itself, especially in young persons where the petro-squamous suture has not as yet solidified. This fact has probably given rise to the impression that cerebral abscess is much more common in children than in adults, as compared with cerebellar. Only a thin layer of bone separates the **floor** from the internal jugular vein; the mastoid cells communicate with the cavity, and are also in close relation with the lateral sinus; and, lastly, the internal carotid artery is only separated from the anterior wall by a thin plate of bone. The orifice of the Eustachian tube and the lower edge of the tympanic membrane, it should be remembered, are not on a level with the floor of the tympanic cavity, but some little distance above it; a well is thus formed in which pus may collect and ferment, even though the membrane be perforated. Hence the importance of frequently washing out the cavity with a solution of warm boracic lotion, and the daily use of POLITZER's bag for a week or ten days.

CEREBRAL ABSCESS.

Cerebral Abscess following Ear Disease.—Cerebral abscess is one of the most serious complications of disease of the middle or internal ear. It may be situated either in the temporo-sphenoidal lobe of the cerebrum, which it reaches by passing in some way through the roof of the tympanic cavity, or in the cerebellum, which it reaches either from the mastoid process, or by passing through the internal ear and internal auditory meatus; from the latter source it may occasionally attack the pons and medulla. Contrary to the usually received statement it appears that cerebral abscess is much more common than cerebellar at all ages; but, as a matter of fact, this is what might naturally be expected. As regards the exact nature of the abscess it is impossible to say with certainty; there can be no doubt, however, that the two conditions under which it is most likely to arise are—*tension* and *sepsis*. The abscess itself may be due—(1) To direct spread of the inflammation from the ear; (2) it may be reflex, or "sympathetic," in nature; (3) it may be due to minute venous or lymphatic septic emboli; or, lastly, (4) the septic inflammation beneath the brain substance has rendered that part of the brain a point of least resistance, and the septic organisms absorbed into the blood from the increased tension find it a suitable soil for their growth and development. In cases of middle ear suppuration, when the tympanic membrane gives way by a *large* opening, the tension is relieved, but the chances of the admission of septic organisms are very much increased; the pus tends to pass backwards and involve the mastoid cells, which form a specially favourable seat for the reception and lodgment of fermented and fermenting pus. It is also evident that tension will be increased when, as not unfrequently happens, granulations and polypi spring up from the carious cavity and block up the openings of the mastoid cells, or even the external auditory meatus itself. This is now, *par excellence,* the condition that is most likely to result in cerebral abscess.

It has been observed that the temperature is often abnormally low in cerebral abscess, and the pulse unnaturally slow; the pupils are dilated, and there is much mental confusion and torpor, usually passing on, unless relieved, to coma and death.

Sometimes there is a spot tender to pressure, or percussion over the temporo-sphenoidal lobe. Further, weakness of the muscles of the angle of the mouth, ataxic speech, word deafness, and optic neuritis have been observed. Hemiplegia coming on with signs of compression many weeks after a head injury, is said to point to cerebral abscess. Cerebral abscess may also arise from disease of the nasal cavities; it is often present in pyæmia, and not unfrequently follows injuries to the head.

Diagnosis.—It is impossible to distinguish with certainty between this condition and diffuse suppurative meningitis, and thrombosis of one or other of the cerebral sinuses. In **meningitis,** however, there is, in the first instance at any rate, high temperature and rapid pulse, intense headache, tenderness to pressure or tapping over the cerebrum, contracted pupils, and probably hemiplegia or unilateral spasm; and in **phlebitis and thrombosis** of the sinuses these symptoms would be accompanied with **signs of pyæmia,** such as repeated rigors, high temperature, profuse sour-smelling perspiration, peculiar waxy tint of the skin, peculiar odour of the breath and metastatic abscesses, as well as swelling in the course of the internal jugular vein and side of face. If the internal jugular vein be the seat of the thrombosis there will be signs of pressure on the glosso-pharyngeal, vagus, and spinal accessory causing spasm of the sterno-mastoid, and also on the hypo-glossal nerve, together with tenderness at the side of the neck; should the thrombus be situated in the cavernous sinus there will be signs of pressure on the third, fourth, and sixth nerves, causing paralysis or spasm of the muscles supplied, and also on the ophthalmic vein, causing suffusion of the eyes and possibly unilateral optic neuritis. In a series of cases collected by Dr M'Bride, he found that when the abscess involved the tympanum and mastoid, cerebral abscess was much more common than cerebellar, but that when the tympanum and labyrinth were involved, then cerebellar abscess was the rule. Diffuse purulent meningitis is also common, especially when the tympanum and labyrinth are the seat of suppuration.

To distinguish between the cerebral and cerebellar forms is by no means easy. In the **cerebellar** form there will probably be severe occipital headache, vomiting and vertigo following long existent

ear disease; there will also probably be *double* optic neuritis, with an absence of bone conduction as tested by the tuning fork applied to the forehead or teeth (M'Bride). This last fact would seem to show that the nerve of hearing is destroyed by the suppurative process having spread to the labyrinth, and thence, through the internal auditory meatus, to the cerebellum; one would also expect some signs of irritation or paralysis of the facial nerve. Mastoid tenderness points rather to cerebellar abscess.

In the **cerebrum** one must chiefly trust, for purposes of diagnosis, to the slow pulse and low temperature, history of previous ear disease, together with signs of pressure on the cavernous sinus and parts near it, especially on the third nerve and venous canal, as well as the probable existence of *unilateral* optic neuritis—or it may be bilateral; also paralysis of the third nerve, œdema of the retina, circumorbital congestion and exophthalmos. One would also expect some interference with hearing, smell, or taste, according as the first, second, or third temporo-sphenoidal convolution is the seat of the abscess.

In abscess of the brain the prognosis is so grave, when left alone, that the general rule is—"**When in doubt trephine.**" The only question is where. In a case of Professor Greenfield's, successfully operated upon by Dr Caird, Professor Chiene advised the opening to be made in the skull near the tip of the temporo-sphenoidal lobe, in the region of the pterion, from the belief that the pus would tend to gravitate downwards and forwards, and also from the fact that there were signs of pressure on the cavernous sinus; the result fully confirmed the correctness of his conclusions. In another case of abscess of the temporo-sphenoidal lobe, successfully operated upon by Mr Barker, the trephine was entered an inch and a quarter behind, and the same distance above, Reid's "base line." Dr M'Bride thinks that the trephine should be entered so as just to expose the roof of the tympanum, and for this purpose proposes that a curved incision should be made over the ear, the auricle dissected downwards, and the trephine entered just above and in front of the external osseous meatus. This incision is advised, both for the purposes of drainage, and also to attack the abscess as near as possible to its source.

In order to reach the cerebellum, Mr Hulke perforated the *occipital* bone about three quarters of an inch behind and inwards

from the mastoid process, the crown of the trephine encroaching upon the inferior curved line; this point is sufficiently removed from either the horizontal or the descending portion of the lateral sinus, and also forms a dependent point for drainage. A horseshoe incision is made through the tissue at this spot, the ends of the incision being a little above the external occipital protuberance, and the bend slightly below the level of a line joining the apices of the mastoid processes. The occipital artery is divided, and must be secured at once. Mr BARKER advocates a point an inch and a half behind the centre of the meatus, and an inch below REID'S "base line."

RÉSUMÉ of the various possible sequelæ of chronic middle-ear suppuration (otitis media):—

1. **Disease of the Mastoid Cells** (see page 574).
2. **Phlebitis and Thrombosis** of lateral sinus. *Signs*—High temperature, rigors, swelling, and pain in the course of the internal jugular vein and side of face, from venous obstruction.
3. **Subdural Abscess.**—This is not common in the adult, and is accompanied by high temperature, probably caries, and POTTS'S puffy swelling.
4. **Meningitis.**—Signs of irritation of the motor and sensory functions of the brain, as well as the special senses, gradually passing into paralysis, coma, and death. Note especially the excited state, the high temperature, the intense headache, and the tenderness to pressure, or tapping, over the cerebrum.
5. **Pyæmia.**—The usual signs of this disease, with secondary abscesses.
6. **Cerebral Abscess.**—Slow pulse, low temperature, great mental torpor, but absence of marked headache or tenderness to pressure or tapping.
7. **Cerebellar Abscess.**—Symptoms supposed to point to this condition are—(1) Occipital headache, (2) cerebral vomiting, (3) retraction of the head, (4) loss or impairment of balancing power, (5) persistent dilatation of the pupil (*mydriasis*), and (6) tonic muscular spasm, most marked on same side as the abscess.

8. **Granulations and Polypi** blocking up the external auditory meatus.
9. **Caries and Necrosis** of different parts of the temporal bone, other than the mastoid process.
10. **Erosion of large vessels,** as the junction of the lateral sinus and internal jugular vein (*sinus* or *gulf* of the internal jugular) or the internal carotid artery.
11. **Spontaneous Perforation of the Mastoid Process** under soft tissues, and the formation of a *pneumatocele* or tumour containing air, the air of course coming from the pharynx up the Eustachian tube to the middle ear, and then through the mastoid cells. It is known by its soft feel, is probably reducible, can be increased in size by forcing air up the Eustachian tube, and is resonant on percussion.
12. **Disease of the Temporo-Maxillary Articulation,** leading to ankylosis more or less complete, and consequent inability to open the mouth. This is more likely to happen in children on account of the presence of the suture between the auditory process and the squamosa-zygomatic portion of the temporal bone.
13. **Suppuration of the Upper Cervical Glands.**—When the deep glands are affected, and if at the same time there is a suspicion of mastoid disease, it may be a matter of considerable difficulty to make out the cause of the constitutional disturbance, for the symptoms may strongly suggest intra-cranial mischief.

MASTOID DISEASE.

Mastoid disease resembles other bone diseases, being either a periostitis and superficial ostitis, or else deep ostitis. In the first there will be great pain, tenderness to pressure, redness and swelling over the bone, as it is comparatively superficial—the swelling making the auricle stand out from the head; in the second form there will also be great pain, but no swelling nor redness, though there may be tenderness on tapping or deep pressure. In both the great danger is pyæmia, as in all bone disease where

there is putrid pus under high tension, osteophlebitis, and septic thrombosis, which thrombi break down and form minute septic emboli, with all their secondary results. The question is, *when* to interfere? It is doubtful whether one ought to trephine without first having signs of tenderness to pressure, superficial or deep; and again, it will probably do little good if there are already signs of widespread septic infection, or diffuse suppurative meningitis. Still, even in such a condition, opening and washing out cannot place the patient in any worse a condition than before, and *may* do a great deal of good.

In **trephining the mastoid antrum**, a small-headed trephine should be used, and it must be entered on a level with the *upper* wall of, and as near the meatus as possible, and it should be directed forwards, inwards, and slightly upwards. Probably a less complicated form of instrument, such as a gimlet or gouge, is all that is required, and will be equally efficient in cases demanding this operation. In either case, were the instrument directed at right angles to the mastoid process, there is great danger of going too deeply and opening the lateral sinus, and yet missing the object of the operation. An **incision** should be made from below upwards, parallel with the attachment of the auricle and half-an-inch behind it, so as to avoid the posterior auricular artery. After having made an opening it must be treated in the same way as any other suppurating cavity—viz., introduce a drainage tube through the mastoid cells, or antrum, into the tympanic cavity, and wash it out occasionally with some warm antiseptic fluid, such as boracic acid, in both directions, from the external auditory meatus, and also from the drainage tube. For the relief of superficial inflammation, or abscess of the mastoid process, a similar incision should be used.

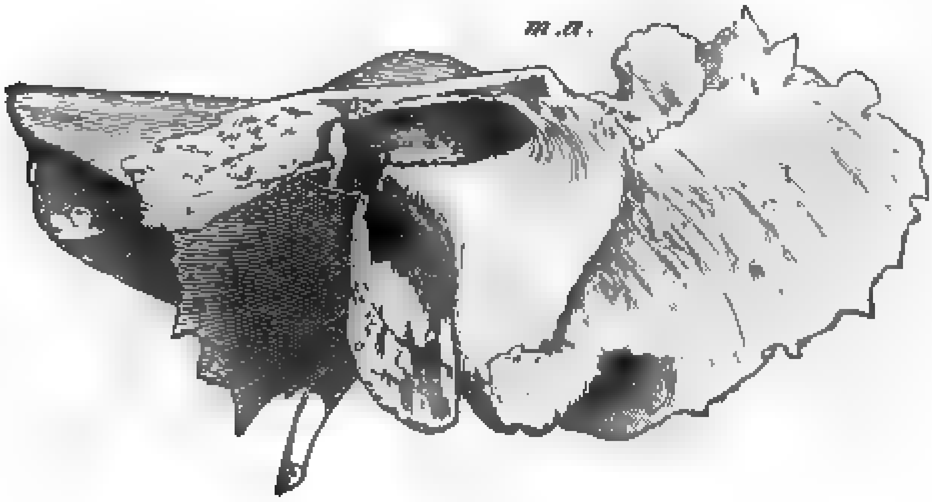
Fig. 119, from a specimen in the possession of Dr SYMINGTON, shows very well the relation of the mastoid antrum to the attic, or upper chamber, of the tympanic cavity, and to the external auditory meatus. In the specimen in question the squamosa-mastoid, or external petro-squamous suture, was persistent, so that the temporal bone consisted of two parts—one, formed by the united petro-mastoid, tympanic, and styloid elements; the other, by the squamosa. In the figure the squamosa has been disarticulated

from the rest of the temporal bone; in this way the attic, or upper chamber, of the tympanic cavity and the mastoid antrum have been exposed, as the squamosa forms the outer wall of these spaces.

Fig. 119.

POSITION OF THE MASTOID ANTRUM.

(SYMINGTON.)



m. a.—Mastoid Antrum.

It should be remembered, as Dr SYMINGTON has pointed out, that there are no mastoid cells, properly so called, in infants; in them the mastoid simply contains a single air cell, which communicates with the upper chamber or attic of the tympanum. It is known as the *mastoid antrum.* It has also been shown that up to puberty the mastoid process is finely cancellous, but after this time air cells are developed; in many adults, however, the development of air cells is imperfect, and in some entirely absent. In all cases, however, both in children and adults, the mastoid antrum is present, and, according to Mr BARKER, is the point to be aimed at in suppuration of the mastoid process.

END OF VOL. I.

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